

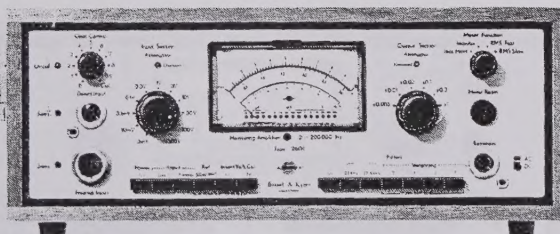
# 2606

# Instructions and Applications



## Measuring Amplifier Type 2606

A portable instrument capable of the complete range of sound, vibration and voltage measurements. With a B & K microphone it conforms to IEC R 179 for Precision Sound Level Meters, the proposed IEC Recommendation for Impulse Precision Sound Level Meters and to DIN 45 633 parts 1 and 2.



BRÜEL & KJÆR



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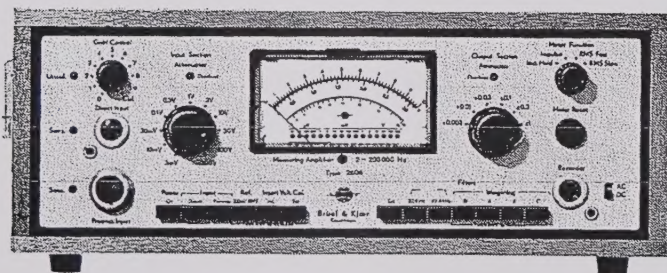
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## 1. INTRODUCTION

The 2606 is a portable instrument capable of the complete range of sound and vibration measurements. It combines extreme versatility with a wide measuring range and laboratory precision.

It is basically a wide range voltmeter but it has interchangeable scales enabling direct reading of voltage, sound level, absorption coefficient, dB, acceleration and power spectral density, for various transducer sensitivities with the range setting indicated on the scale.

Used with one of the B & K condenser microphones, the 2606 becomes a precision sound level meter to IEC Recommendation 179 and an impulse sound level meter to the proposed IEC Recommendation and German DIN 45 633 parts 1 and 2. The meter indicates true RMS for signals of high crest factor and the meter circuit also has a maximum RMS hold for convenient measurement of transient signals. It also contains the internationally standardized sound level meter frequency weighting networks A, B and C and the proposed D network.

Other features are an internal calibration voltage, facilities for insert voltage calibration of microphones. The frequency range can be limited to audio frequencies and there are overload indicators and relays on input and output amplifier sections.

Frequency analysis can be accomplished in conjunction with various types of filter sets. The output signal can be recorded in AC or DC form. AC is normally used for the recording of ordinary sound or vibration signals whilst DC is principally intended for the recording of impulse sound.

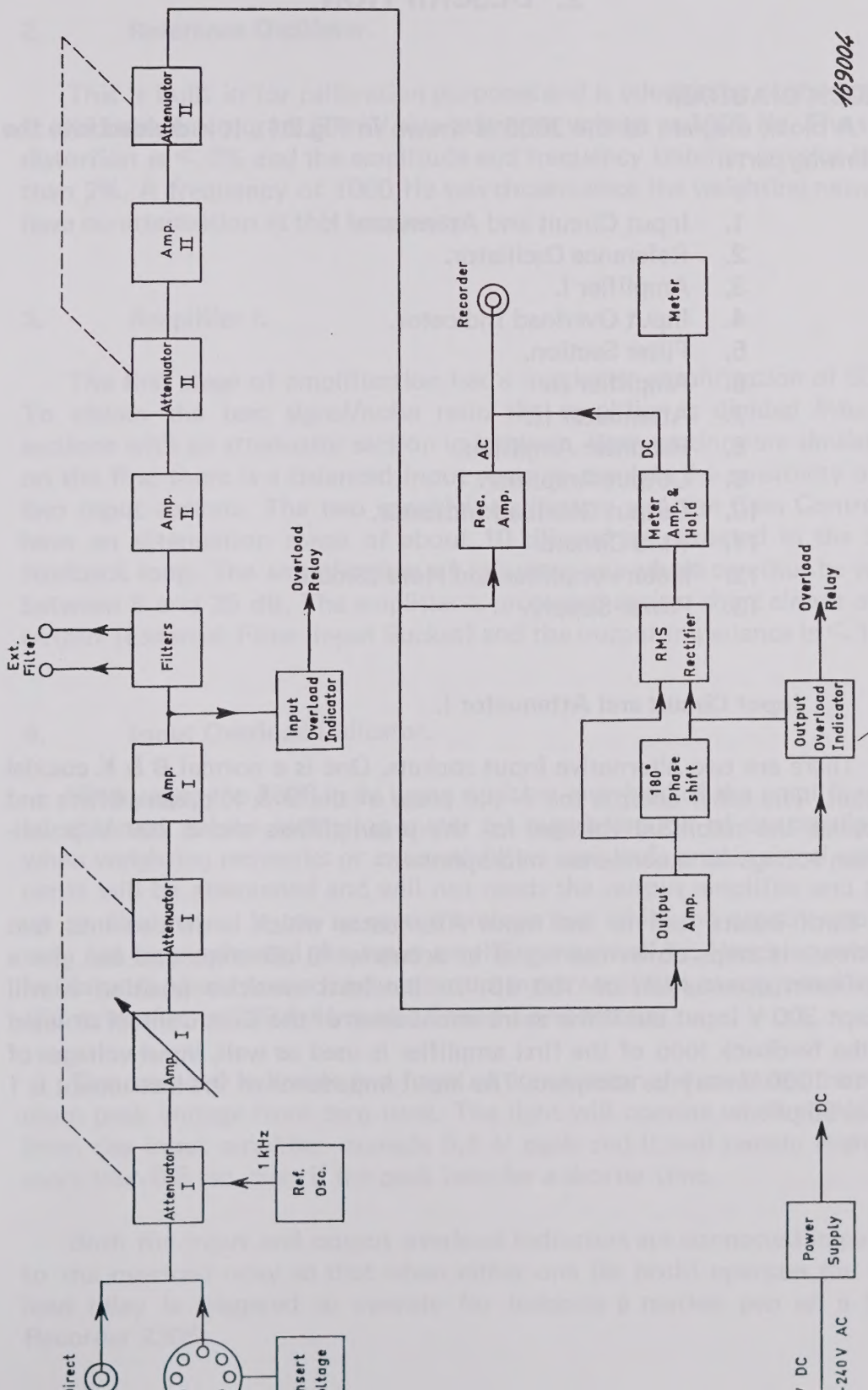


Fig.2.1. Block diagram

169004

## 2. DESCRIPTION

### BLOCK DIAGRAM

A block diagram of the 2606 is shown in Fig.2.1.. It is divided into the following parts:

1. Input Circuit and Attenuator I.
2. Reference Oscillator.
3. Amplifier I.
4. Input Overload Indicator.
5. Filter Section.
6. Amplifier II.
7. Attenuator II.
8. Recorder Amplifier.
9. Output Amplifier.
10. Output Overload Indicator.
11. RMS Circuit.
12. Meter Amplifier and Hold Circuit.
13. Power Supply.

#### 1. Input Circuit and Attenuator I.

There are two alternative input sockets. One is a normal B & K coaxial socket. The other accepts the 7-pin plugs of the B & K preamplifiers and supplies the stabilized voltages for the preamplifiers and a 200 V polarization voltage for a condenser microphone.

Both inputs lead to the Input Attenuator which is divided into two sections. It steps down the signal in accurate 10 dB steps and can give a maximum attenuation of 100 dB. In the least sensitive position it will accept 300 V input but if the extra attenuation of the Gain Control situated in the feedback loop of the first amplifier is used as well, input voltages of up to 1000 V may be accepted. The input impedance of the instrument is  $1\text{ M}\Omega//50\text{ pF}$ .

## **2. Reference Oscillator.**

This is built in for calibration purposes and is selected by push-button. It produces an accurate 50 mV sine reference voltage at 1000 Hz. The signal distortion is  $< 2\%$  and the amplitude and frequency stability are also better than 2%. A frequency of 1000 Hz was chosen since the weighting networks have no attenuation at this frequency.

## **3. Amplifier I.**

The first stage of amplification has a maximum amplification of 50 dB. To obtain the best signal/noise ratio the amplifier is divided into two sections with an attenuator section in between. Both sections are similar but on the first there is a balanced input stage to regulate the sensitivity of the two input sockets. The two sensitivity adjusters and the Gain Control all have an attenuation range of about 10 dB and are situated in the same feedback loop. The amplification of this stage as a whole can thus be varied between 5 and 25 dB. The amplifier is protected against short circuit of the output (External Filter Input Socket) and the output impedance is  $< 10\Omega$ .

## **4. Input Overload Indicator.**

When using the 2606 in its linear position, overload of the amplifiers can be observed on the indicating meter by overdeflection of the needle, but when weighting networks or external filters are used, certain signal components will be attenuated and will not reach the output amplifier and show up on the meter. It can be seen therefore that while the output amplifier may not be overloaded the input amplifier may well be. Hence an overload indicator is placed immediately after the input amplifier, as suggested by the IEC extension to 179 for Impulse Sound Level Meters.

The overload indicator is a form of comparator and measures the maximum peak voltage from zero level. The light will operate when the output from the input amplifier exceeds 5.6 V peak and it will remain alight for more than 0.5 sec. even if the peak lasts for a shorter time.

Both the input and output overload indicators are connected in parallel to the overload relay so that when either one (or both) operates the overload relay is triggered to operate for instance a marker pen on a Level Recorder 2305.

## 5. Filter Section

This consists of 6 filters all having an input impedance of 146 k $\Omega$ .

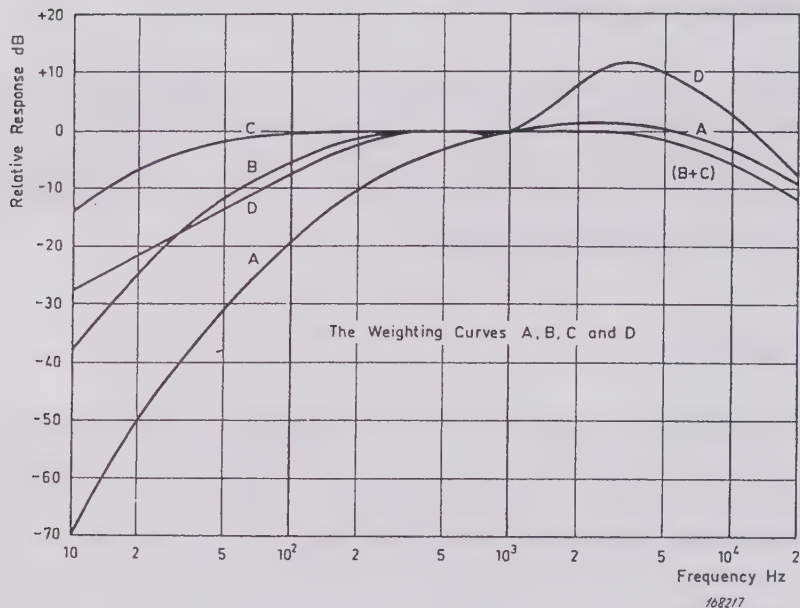


*Fig.2.2. A, B, C and D weighting networks*

A graph showing the characteristics of the A, B, C, and D weighting networks is shown in Fig.2.2.. The A, B and C networks comply with the basic shape and tolerances set by the IEC Recommendation 179 and the proposed D network has also been designed to lie within these same tolerances (Fig.2.3.). It should be noted that these tolerances apply only to the microphone and preamplifier in a free sound field for normal incidence of the sound waves. Therefore the microphone should be kept away from the meter and the operator by means of a long extension cable.

The high-pass and low-pass filters are provided to limit the instrument's frequency range to audio frequencies. They can be connected in series with the weighting networks and may also be used with external filters.

The HP-filter is an active 6-pole filter. No coils are used because at this low frequency they would be affected by noise from the mains transformer. The characteristics of the HP-filter are shown in Table I and a graph in Fig.2.4 . The slopes of both the HP and LP-filters are the same as those set

| Frequency<br>Hz | Curve A<br>dB | Curve B<br>dB | Curve C<br>dB | Curve b<br>dB | IEC Tolerance<br>limits dB |      | B&K Tolerance<br>limits dB |      |
|-----------------|---------------|---------------|---------------|---------------|----------------------------|------|----------------------------|------|
| 10              | -70.4         | -38.2         | -14.3         | -27.6         | 5                          | -∞   | 3                          | -3   |
| 12.5            | -63.4         | -33.2         | -11.2         | -25.6         | 5                          | -∞   | 3                          | -3   |
| 16              | -56.7         | -28.5         | -8.5          | -23.5         | 5                          | -∞   | 3                          | -3   |
| 20              | -50.5         | -24.2         | -6.2          | -21.6         | 5                          | -5   | 3                          | -3   |
| 25              | -44.7         | -20.4         | -4.4          | -19.6         | 5                          | -5   | 2                          | -2   |
| 31.5            | -39.4         | -17.1         | -3.0          | -17.6         | 3                          | -3   | 1.5                        | -1.5 |
| 40              | -34.6         | -14.2         | -2.0          | -15.6         | 3                          | -3   | 1.5                        | -1.5 |
| 50              | -30.2         | -11.6         | -1.3          | -13.6         | 3                          | -3   | 1.5                        | -1.5 |
| 63              | -26.2         | -9.3          | -0.8          | -11.6         | 3                          | -3   | 1.5                        | -1.5 |
| 80              | -22.5         | -7.4          | -0.5          | -9.6          | 2                          | -2   | 1.5                        | -1.5 |
| 100             | -19.1         | -5.6          | -0.3          | -7.8          | 1                          | -1   | 1                          | -1   |
| 125             | -16.1         | -4.2          | -0.2          | -6.0          | 1                          | -1   | 1                          | -1   |
| 160             | -13.4         | -3.0          | -0.1          | -4.4          | 1                          | -1   | 1                          | -1   |
| 200             | -10.9         | -2.0          | 0             | -3.1          | 1                          | -1   | 1                          | -1   |
| 250             | -8.6          | -1.3          | 0             | -1.9          | 1                          | -1   | 1                          | -1   |
| 315             | -6.6          | -0.8          | 0             | -1.0          | 1                          | -1   | 1                          | -1   |
| 400             | -4.8          | -0.5          | 0             | -0.3          | 1                          | -1   | 1                          | -1   |
| 500             | -3.2          | -0.3          | 0             | 0             | 1                          | -1   | 1                          | -1   |
| 630             | -1.9          | -0.1          | 0             | -0.1          | 1                          | -1   | 1                          | -1   |
| 800             | -0.8          | 0             | 0             | -0.4          | 1                          | -1   | 1                          | -1   |
| 1000            | 0             | 0             | 0             | 0             | 1                          | -1   | 1                          | -1   |
| 1250            | 0.6           | 0             | 0             | 1.9           | 1                          | -1   | 1                          | -1   |
| 1600            | 1.0           | 0             | -0.1          | 5.4           | 1                          | -1   | 1                          | -1   |
| 2000            | 1.2           | -0.1          | -0.2          | 8.0           | 1                          | -1   | 1                          | -1   |
| 2500            | 1.3           | -0.2          | -0.3          | 10.0          | 1                          | -1   | 1                          | -1   |
| 3150            | 1.2           | -0.4          | -0.5          | 11.0          | 1                          | -1   | 1                          | -1   |
| 4000            | 1.0           | -0.7          | -0.8          | 10.9          | 1                          | -1   | 1                          | -1   |
| 5000            | 0.5           | -1.2          | -1.3          | 10.0          | 1.5                        | -1.5 | 1.5                        | -1.5 |
| 6300            | -0.1          | -1.9          | -2.0          | 8.5           | 1.5                        | -2   | 1.5                        | -2   |
| 8000            | -1.1          | -2.9          | -3.0          | 6.0           | 1.5                        | -3   | 1.5                        | -3   |
| 10000           | -2.5          | -4.3          | -4.4          | 3.0           | 2                          | -4   | 2                          | -4   |
| 12500           | -4.3          | -6.1          | -6.2          | -0.4          | 3                          | -6   | 3                          | -6   |
| 16000           | -6.6          | -8.4          | -8.5          | -4.4          | 3                          | -∞   | 3                          | -∞   |
| 20000           | -9.3          | -11.1         | -11.2         | -8.1          | 3                          | -∞   | 3                          | -∞   |

Fig 2.3 Weighting network tolerances

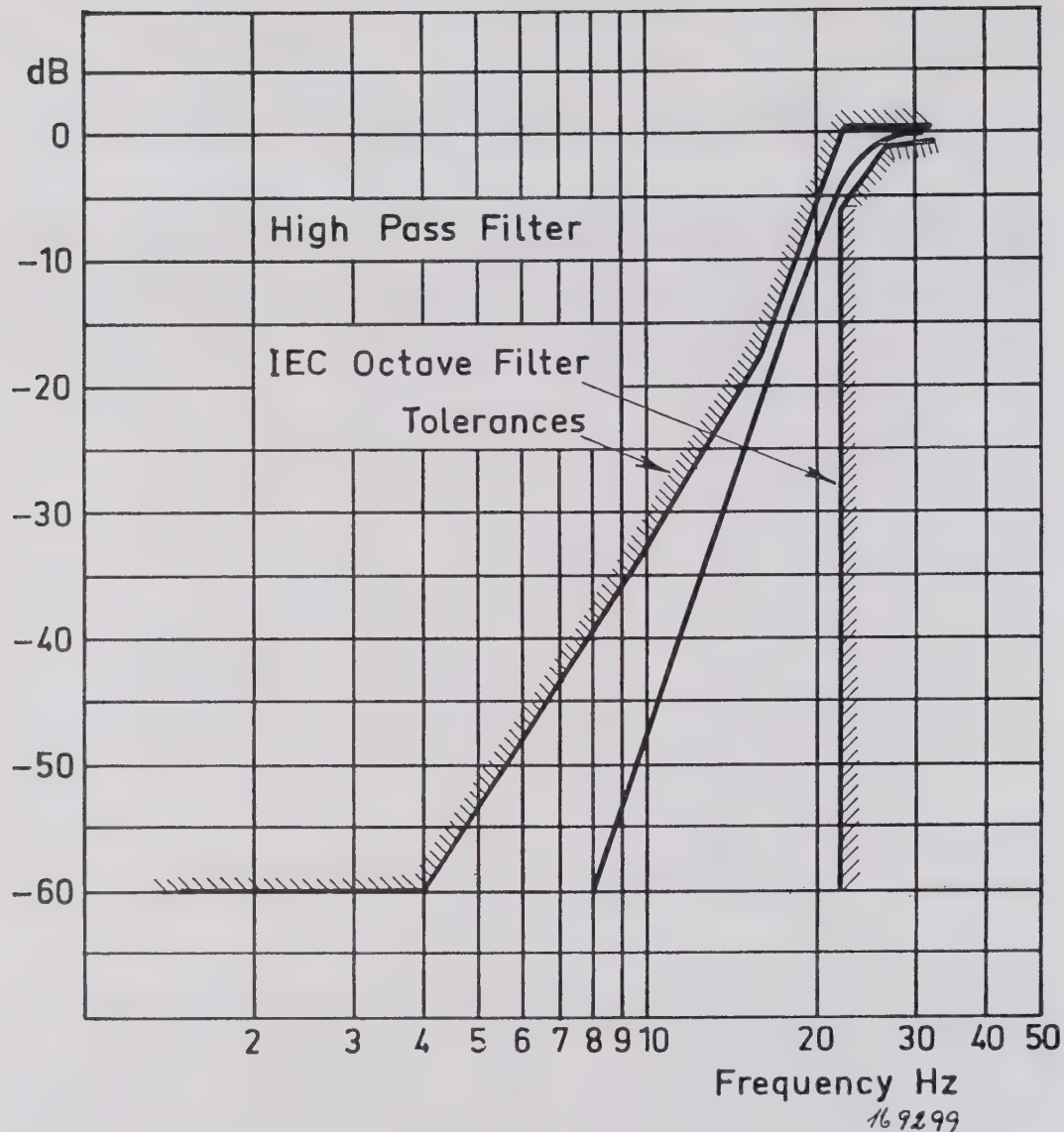


*Fig.2.4. High-pass filter characteristics*

by the IEC for octave filters and have the same tolerances. (See IEC Recommendation 225).

For the LP-filter a 5-pole Butterworth filter is sufficient to meet the specifications. The characteristics are in Table II and graph in Fig.2.5.

| Frequency (Hz) | Attenuation from linear (dB) |
|----------------|------------------------------|
| 32             | $\pm 0.5$                    |
| 22.4           | 3 $\pm 1$                    |
| 16             | > 18                         |
| 8              | > 40                         |
| 4              | > 60                         |
| 2              | > 70                         |

Table I

| Frequency (kHz) | Attenuation from linear (dB) |
|-----------------|------------------------------|
| 19              | $\pm 0.5$                    |
| 22.4            | 3 $\pm 1$                    |
| 32              | > 18                         |
| 64              | > 40                         |
| 125             | > 60                         |
| >125            | > 60                         |

Table II

## 6. Amplifier II.

To obtain the best possible signal to noise ratio the output amplifier is also divided up into several stages.

The first stage is divided into two sections. The first section is combined with a low-pass filter (to cut out frequencies  $> 200$  kHz) and the first section of the output attenuator. The second section is combined with the second section of the output attenuator.

## 7. Attenuator II.

The two sections of the output attenuator step down the signal in accurate 10 dB steps with a maximum attenuation of 50 dB.

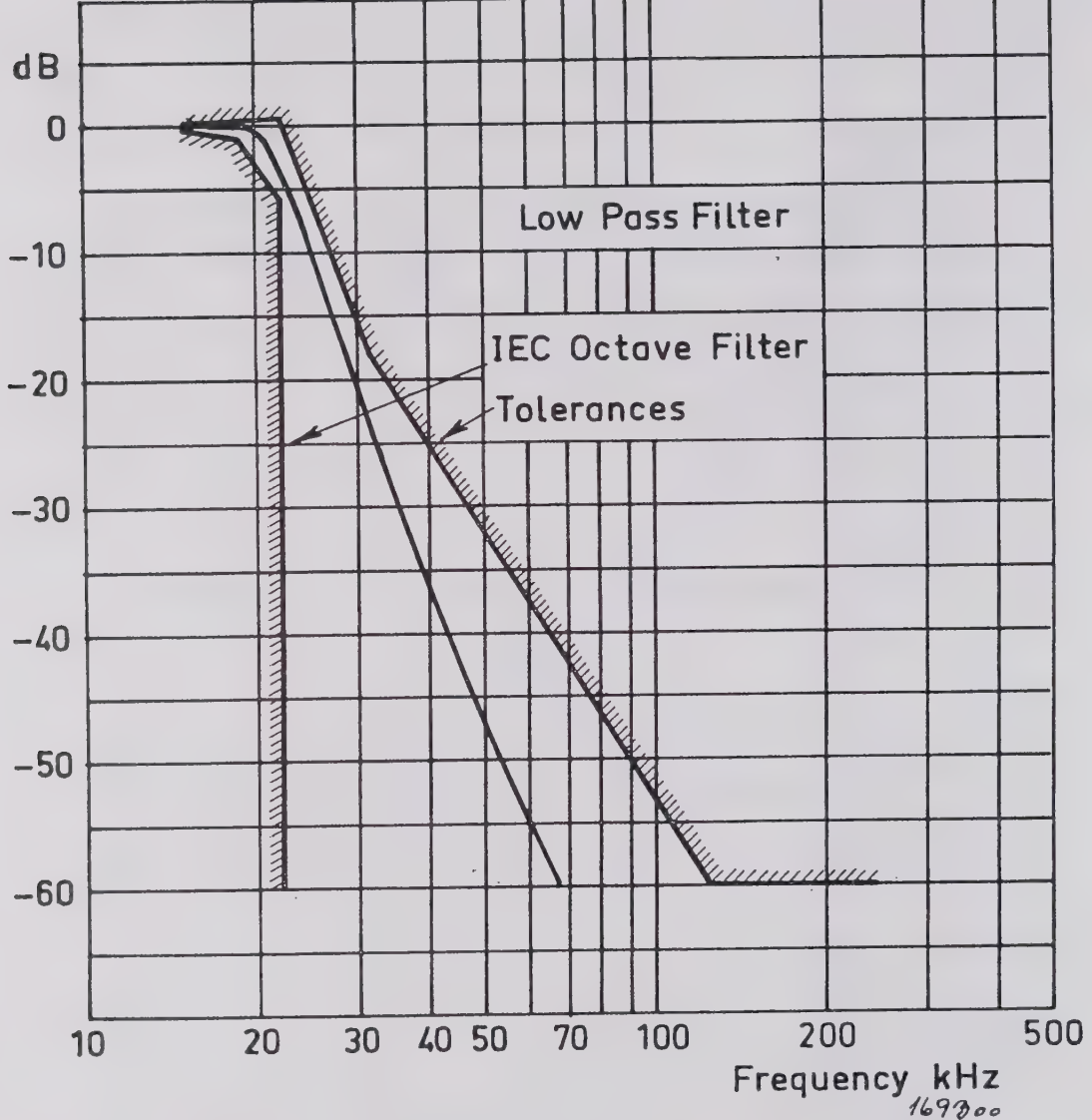


*Fig.2.5. Low-pass filter characteristics*

## 8. Recorder Amplifier.

When an AC recording is made the signal from the Output Attenuator is fed direct to a normal class B amplifier. The maximum amplification produced throughout the output section is then 64 dB and the maximum output voltage of 5 V RMS corresponds to full scale meter deflection. The amplifier is protected against short circuit at the recorder socket and the output impedance is  $< 50\Omega$ .

## **9. Output Amplifier**

When a meter reading or a DC recording is required the signal from the Output Attenuator is passed direct to this section.

The amplifier is of the push—pull type (hence the  $180^\circ$  phase shift) and feeds the RMS rectifier.

To give the instrument a large operating temperature range, silicone diodes are used in the RMS rectifier. A relatively large voltage drop occurs across them so a certain amount of distortion, is produced in the rectified signal. To compensate for this distortion further diodes are inserted in the feedback loop of the output amplifier. These produce a characteristic distortion which counteracts the distortion due to the rectifying diodes so a correct signal is passed on to the meter.

This is the reason for using a separate final amplifier stage when AC recordings are made.

## **10. Output Overload Indicator**

The IEC extension of Recommendation 179 proposes that in order to safeguard against harmonic distortion due to the overdriving of the amplifier by signals with too high a peak value, overload indicators should be placed at the amplifier stage before a filter and before the meter rectifier.

An output overload indicator is thus fitted before the meter rectifier and comes into operation when the output voltage exceeds 56 V peak. Its mode of operation is similar to that of the input overload indicator and it is connected to the overload relay as previously mentioned.

## **11. RMS Circuit**

In principle RMS circuits consist of squaring, averaging and root extracting sections (Fig.2.6a.). The actual circuit (Fig.2.6b.) is made with variable squaring i.e. the parameter of the parabola is a function of the voltage on the averaging condenser. It can be shown that the two circuit principles are identical, except for the RC product which must be twice as large in the latter case.

The mode of operation of the RMS circuit can be understood by considering Fig.2.6a. If a step voltage  $V_1$  is applied to the input, the voltage  $E$  at the output will rise according to the function

$$E = K_1 V_1 \sqrt{1 - e^{-\frac{t}{RC}}} \quad (i)$$

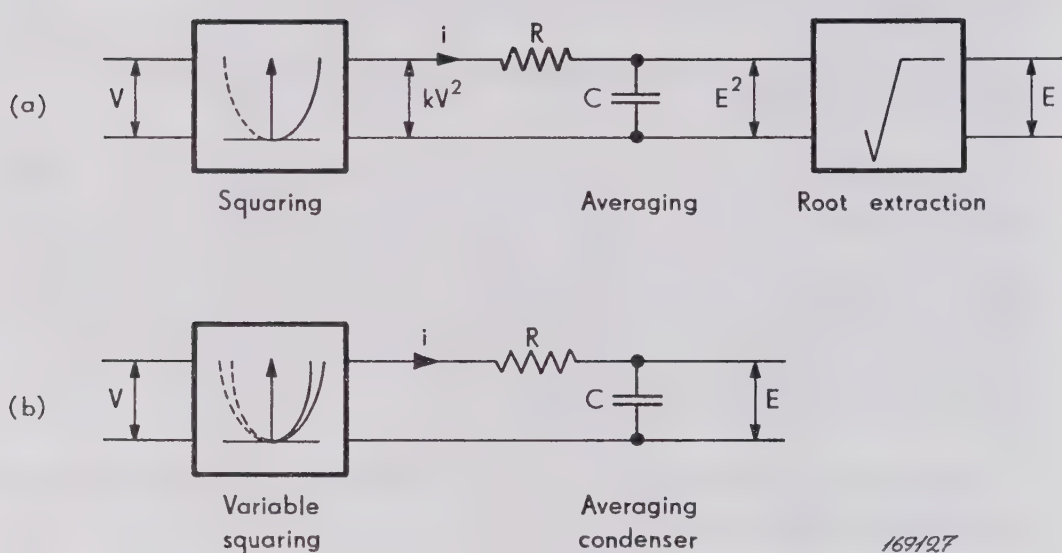


Fig.2.6a. Principal sections of RMS circuits

Fig.2.6b. RMS circuit of 2606

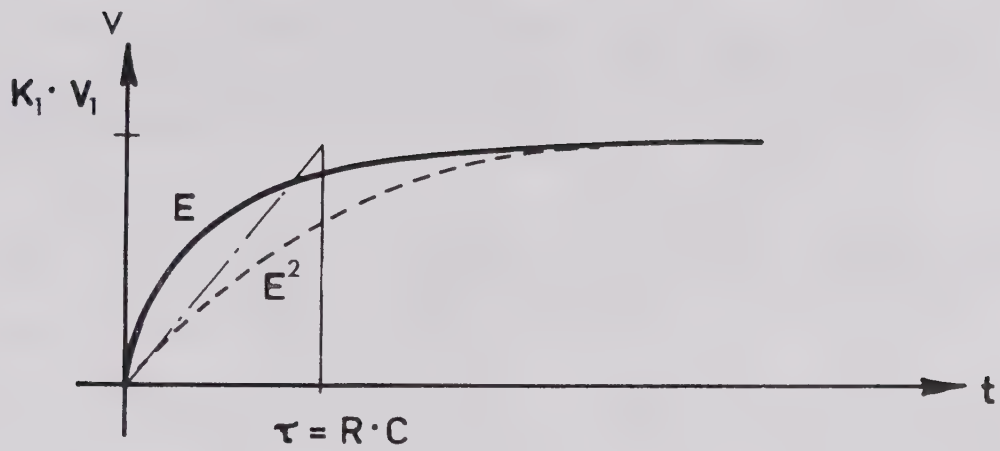
This function is the basis for the impulse SL-meter standard's requirements for single impulse response. See Fig.2.7a.

If the input voltage now steps down from a constant value  $V_1$  to 0,  $E$  will decrease according to the function

$$E = K_1 V_1 e^{-\frac{t}{2RC}} \quad (ii)$$

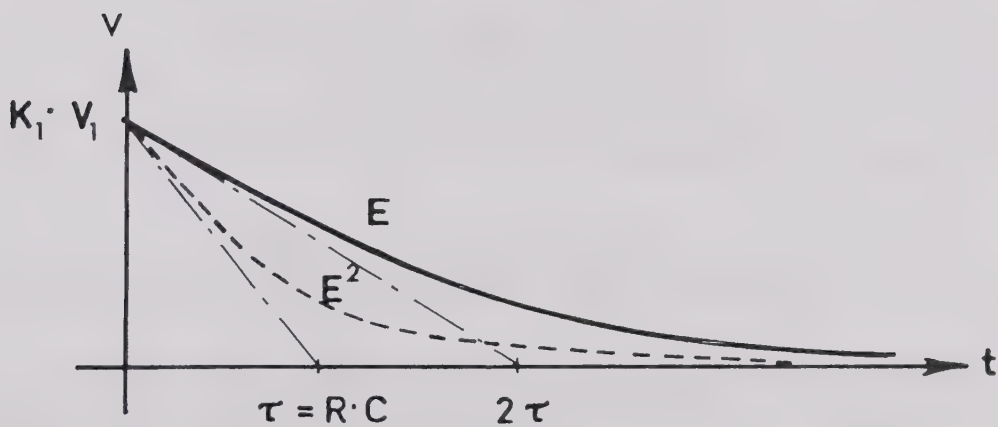
See Fig.2.7b.

When repeated impulses are applied with a repetition time of more than 5 times the time constant  $\tau = RC$  the decay function will influence the measured result as shown in Fig.2.8.



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Fig.2.7a.



169286

Fig.2.7b.

From the figure it can be seen that

$$E_2 = K_1 V_1 \sqrt{1 - e^{-\frac{s}{\tau}}} \quad E_1 = K_1 V_1 \sqrt{1 - e^{-\frac{s+t}{\tau}}}$$

$$\text{and } E_2 = E_1 e^{-\frac{T-t}{2\tau}}$$

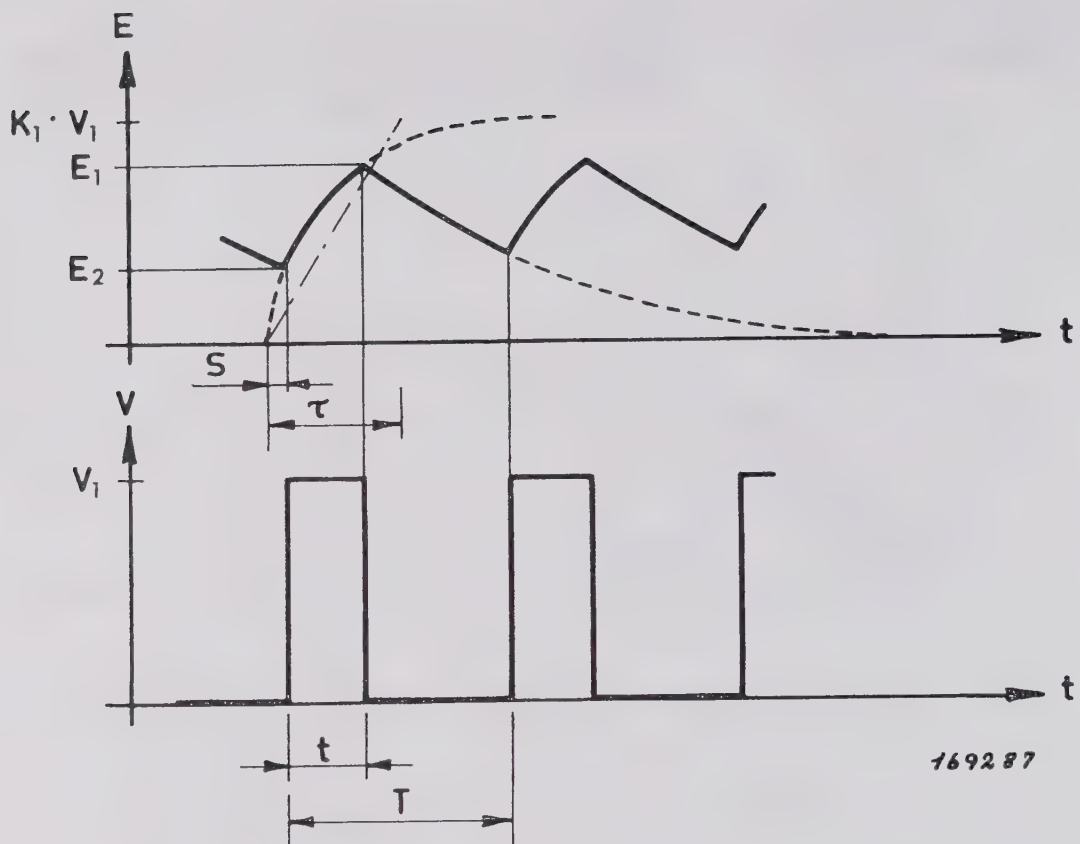


Fig.2.8. Response when  $T = 5 RC$

from which can be obtained

$$E_1 = K_1 V_1 \sqrt{\frac{1 - e^{-t/\tau}}{1 - e^{-T/\tau}}}$$

$$\text{and } E_2 = K_1 V_1 \sqrt{\frac{1 - e^{t/\tau}}{1 - e^{T/\tau}}}$$

It can also be seen that if the time constant  $RC$  is large compared to the periodic time  $T$ , then  $E_1$  and  $E_2$  will be nearly equal. This is the case when the RMS value of the applied voltage is required.

The "peak" voltage  $E_1$ , calculated from

$$E_1 = K_1 V_1 \sqrt{\frac{1 - e^{-\frac{t}{RC}}}{1 - e^{-\frac{T}{RC}}}} \quad (\text{iii})$$

is the basis for the Impulse SL — meter standard's requirements for the response for sequences of impulses. This voltage must then be stored in a hold circuit so that the relatively slow meter can be given sufficient time to respond.

The IEC proposal for Impulse SL — meters states that the mean square value of the signal should be produced with an RC averaging time constant of 35 m.sec. (The corresponding time constants in positions "Fast" and "Slow" are approx. 100 m.sec. and 500 m.sec.).

In the 2606 the squaring section is accurate to within  $\pm 0.5$  dB up to crest factor 10 since 8 breakpoints are used to approximate the squaring curve. Transistors have been used in place of the diodes to produce the breakpoints since they enable high crest factors to be handled. Crest factors up to 10 can be handled at full scale deflection and up to 40 with a lesser meter deflection.

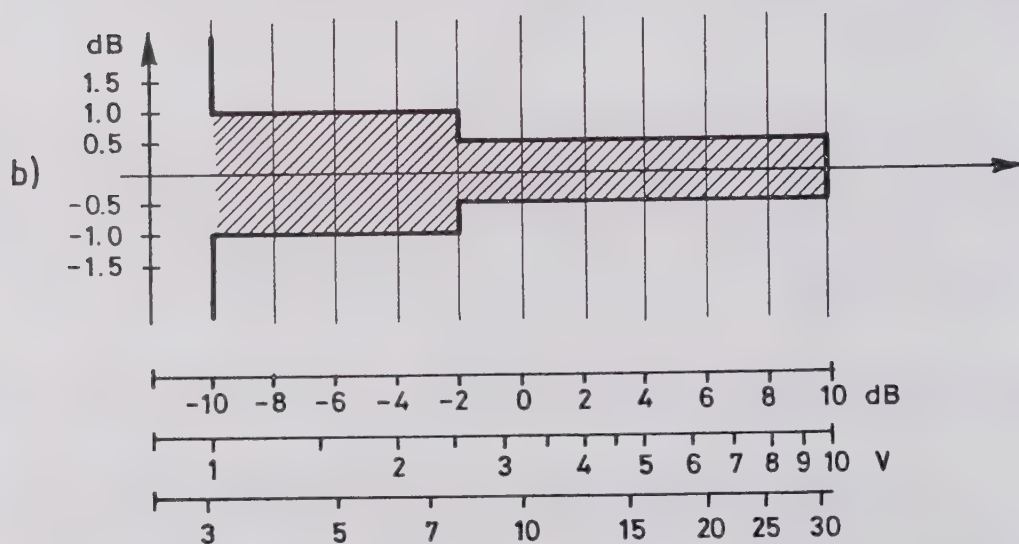
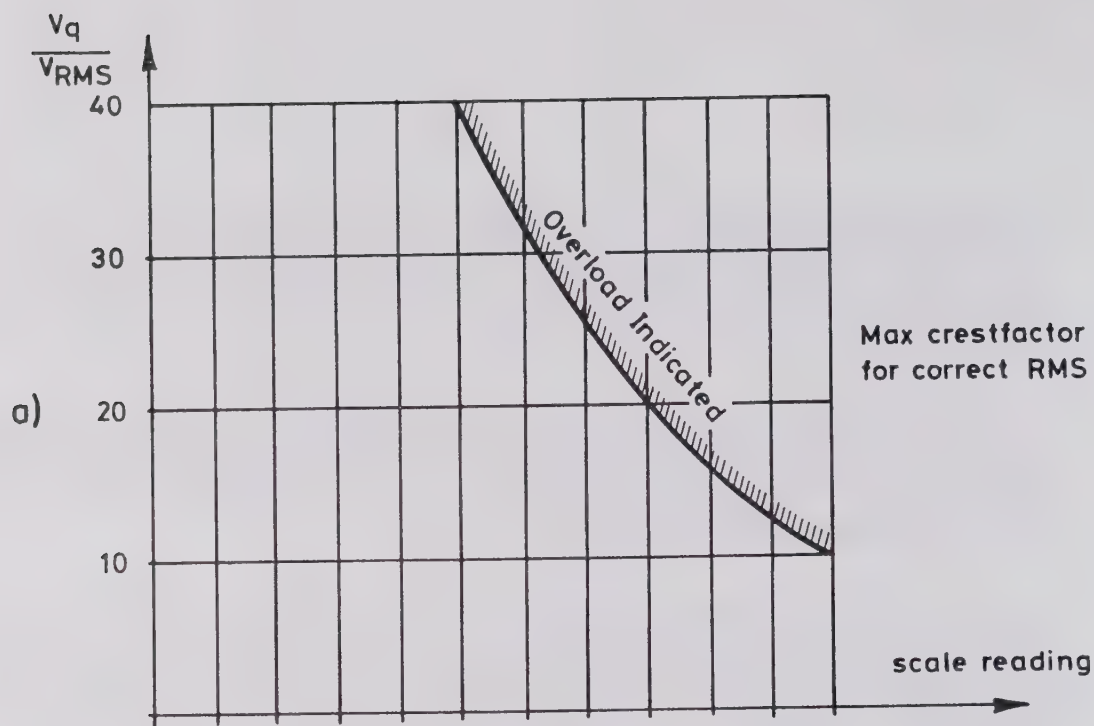
Fig.2.9a. shows the maximum permissible crest factor at a particular scale reading to ensure correct indication of RMS values, and Fig.2.9b. shows the accuracy of scale readings over the complete scale for signals of crest factor up to 40. The maximum SPL's that can be measured accurately with 1" and 1/2" microphones with respect to the crest factor of the signal can be seen in Fig.4.4.

The IEC recommend certain characteristics for the instrument as a whole when measuring impulsive sounds. These are summarised as follows:

If a single burst sinusoidal signal, having a frequency of 2000 Hz, a duration  $t$  and a constant amplitude the reading relative to the reading for the continuous signal shall be as stated in Table III:

Table III. Reading for single impulses.

| Pulse<br>duration $t$ | Reading with respect<br>to reading of<br>continuous signal | Tolerance |
|-----------------------|------------------------------------------------------------|-----------|
| ms                    | dB                                                         | dB        |
| continuous            | 0                                                          |           |
| 50                    | -1.2                                                       | $\pm 1$   |
| 20                    | -3.6                                                       | $\pm 1.5$ |
| 10                    | -6.0                                                       | $\pm 2$   |
| 5                     | -8.8                                                       | $\pm 2$   |



Accuracy of RMS reading for crestfactor up to 10  
 + 0.5 dB for crestfactor up to 20  
 + 1 dB for crestfactor up to 40  
 169301

Fig.2.9a. Maximum permissible crest factor at a particular scale reading

Fig.2.9b. Accuracy of scale readings

If sinusoidal signals having a frequency of 2000 Hz (c/s), a duration of 5 ms and a repetition frequency  $f_p$  are applied with a constant amplitude the reading relative to the reading for the continuous signal shall be as stated in Table IV:

Table IV. Reading for sequences of impulses.

| Repetition frequency | Reading with respect to reading of continuous signal | Tolerance    |
|----------------------|------------------------------------------------------|--------------|
| $f_p$ Hz (c/s)       | dB                                                   | dB           |
| continuous           | 0                                                    |              |
| 100                  | -2.7                                                 | + 1<br>- 0.5 |
| 50                   | -5.1                                                 | + 1.5<br>- 1 |
| 20                   | -7.6                                                 | $\pm 2$      |
| 10                   | -8.5                                                 | $\pm 2$      |
| 5                    | -8.7                                                 | $\pm 2$      |
| 2                    | -8.8                                                 | $\pm 2$      |

The values given in Tables III and IV are shown in Figs.2.10 and 2.11.

## 12. Meter Amplifier and Hold Circuit

As mentioned in the section on the RMS circuit  $E_1$ , from Equation (iii), is the required value for impulse measurements. This maximum value is stored in a circuit the operation of which can be followed with reference to Fig.2.12. When a voltage  $E_1$  is applied to the input of the circuit the operational amplifier will rapidly charge the condenser C to a voltage  $V_2$  very nearly equal to  $E_1$ . If  $E_1$  is then decreased or removed the diode D will cause the voltage on C (nearly equal to  $V_2$ ) to be stored. C will only be discharged by leakage of the components or leakage through a resistor in parallel.

The decay time constant for impulse SL measurements is specified in the IEC proposal for Impulse SL meters at 3 sec.  $\pm 0.5$  sec. Since the figures in this standard are determined only by the peak value of the voltage on the averaging condenser in the RMS circuit, the "Hold" and "Impulse" positions will give rise to the same reading for the figures specified.

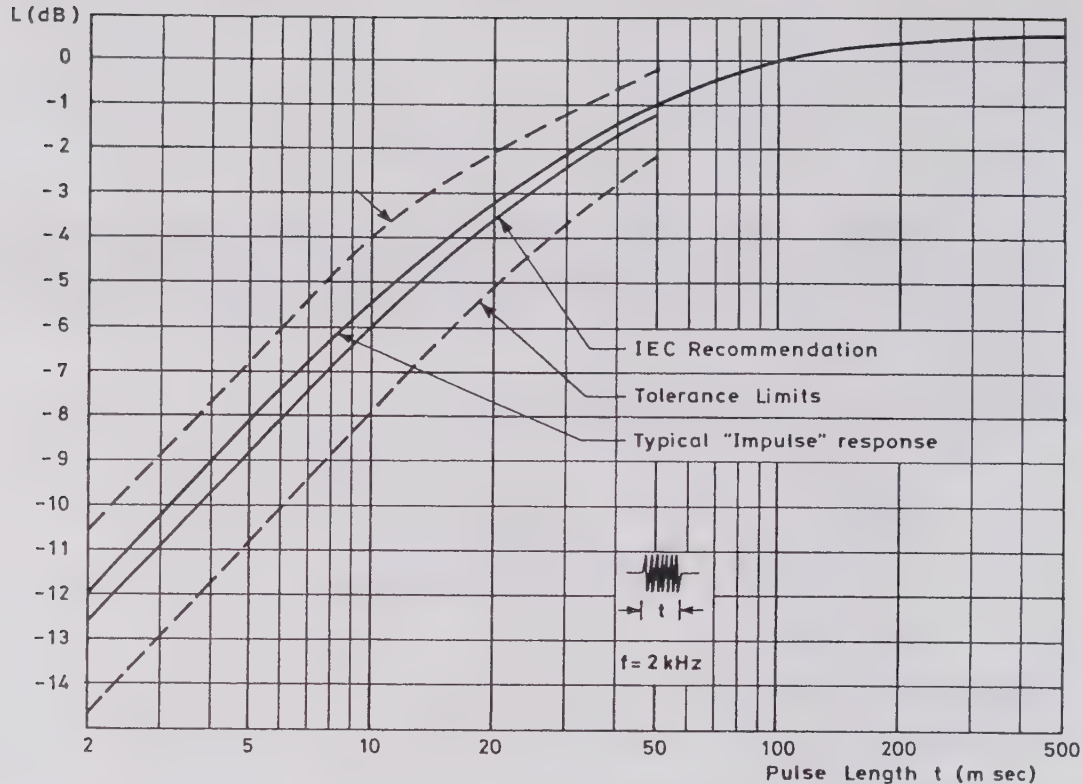


Fig.2.10. Response for single impulses

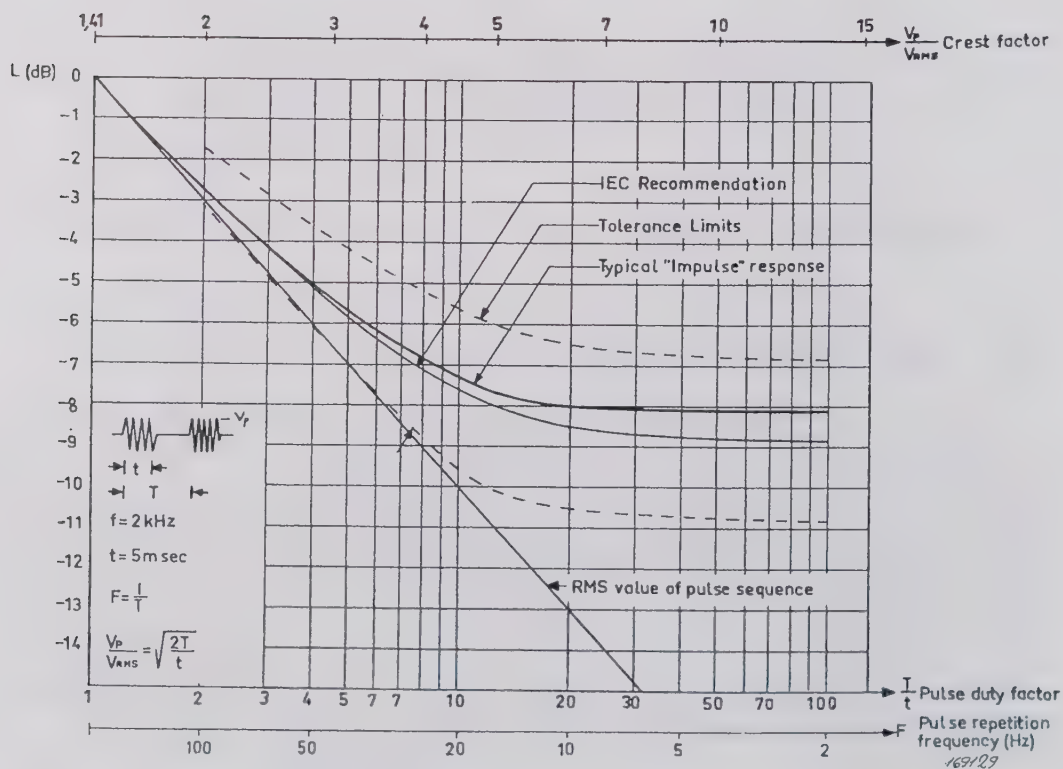


Fig.2.11. Response for sequences of impulses

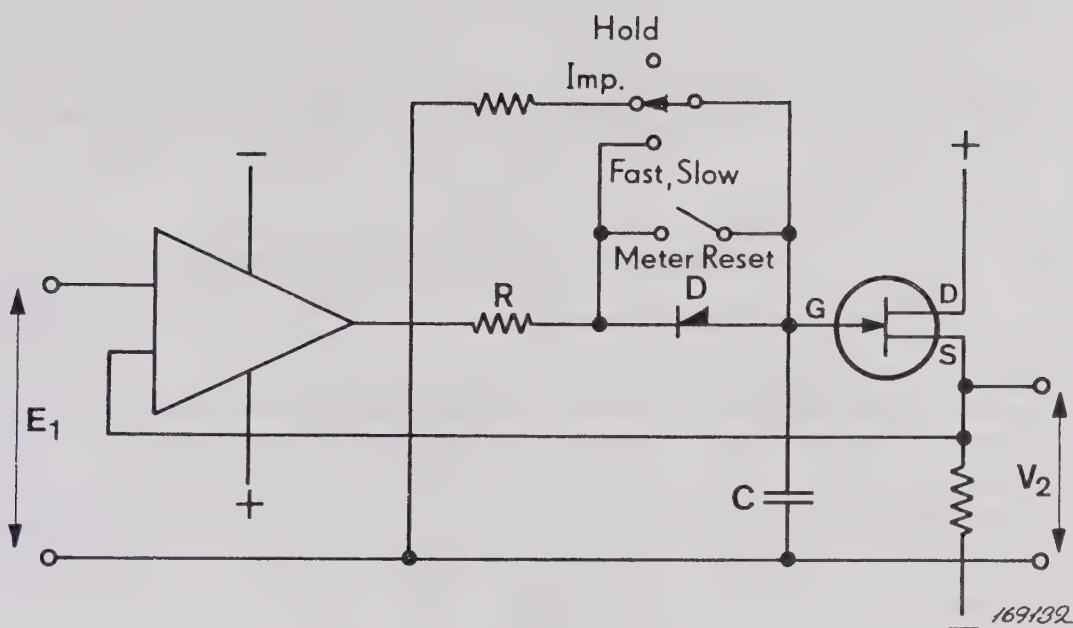


*Fig.2.12. Meter hold circuit*

Measurements on single impulses will, however, be much more easily carried out in the "Hold" position. This position will also be very convenient if the maximum RMS value of a varying SL is wanted.

The hold action can be released by the Meter Reset button which short circuits the diode D. This diode is short circuited automatically when the meter is set to the "Fast" or "Slow" meter dampings. The high amplification of the operational amplifier prevents the voltage drop across the diode having any significant influence on the linearity of the circuit. The decay in the "Hold" position is  $< 0.05$  dB/sec. at  $25^{\circ}\text{C}$ .

### 13. Power Supply

This is split into several sections. Most of the amplifiers are supplied by a stabilized  $\pm 20$  V supply which has a current limiter to protect both the amplifier and the power circuits.

The polarization voltage for the microphone and the high voltage for the output amplifiers are supplied from a 150 V and a 300 V tapping which is subsequently regulated. These amplifiers are also protected against over-current. A 12 V stabilized power supply is used for the microphone pre-

**Fig.2.13. Signal and noise levels of 2606**

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A normal DC—AC push—pull converter is used when the instrument is powered by a 12 V battery. The operating frequency of the converter is about 80 Hz.

## **OVERALL PERFORMANCE OF THE INSTRUMENT.**

### **Signal—to—Noise Ratio**

A diagram of the signal and noise levels in the instrument is shown in Fig.2.13. When the output attenuator switch is in the X 1 position it can be seen that the noise level is always more than 55 dB below the signal. To obtain the best signal—to—noise level the output attenuator should thus be set to give as low amplification as possible, preferably X 1.

### **Overdriving**

Overload indicators are provided on both the input and output sections as already mentioned. The characteristics of these indicators and the capability of the meter response can be seen in the relevant sections of this chapter.

### **Frequency and Phase Characteristics.**

Graphs of both the frequency and phase characteristics can be seen in Figs.2.14, 2.15 and 2.16.

When analysing or measuring complex signals containing many significant harmonics the upper limit of the frequency range should be noted as some harmonics may be attenuated giving an incorrect measurement.

Common amplifiers show phase distortion about a decade or more higher than the lower frequency limit. However, any change in the phase relationship between different components of a signal will not affect its RMS value.

### **Enviromental Effects.**

These can be seen under Specifications 7.

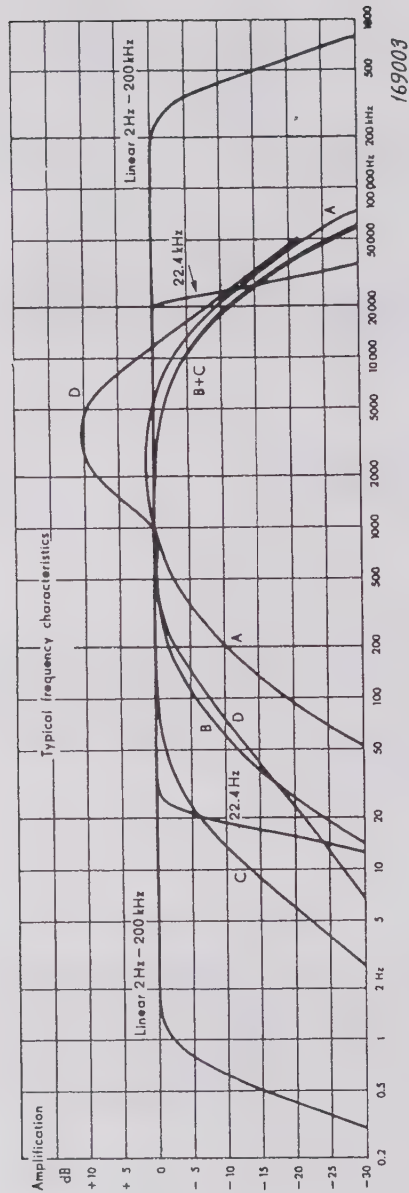
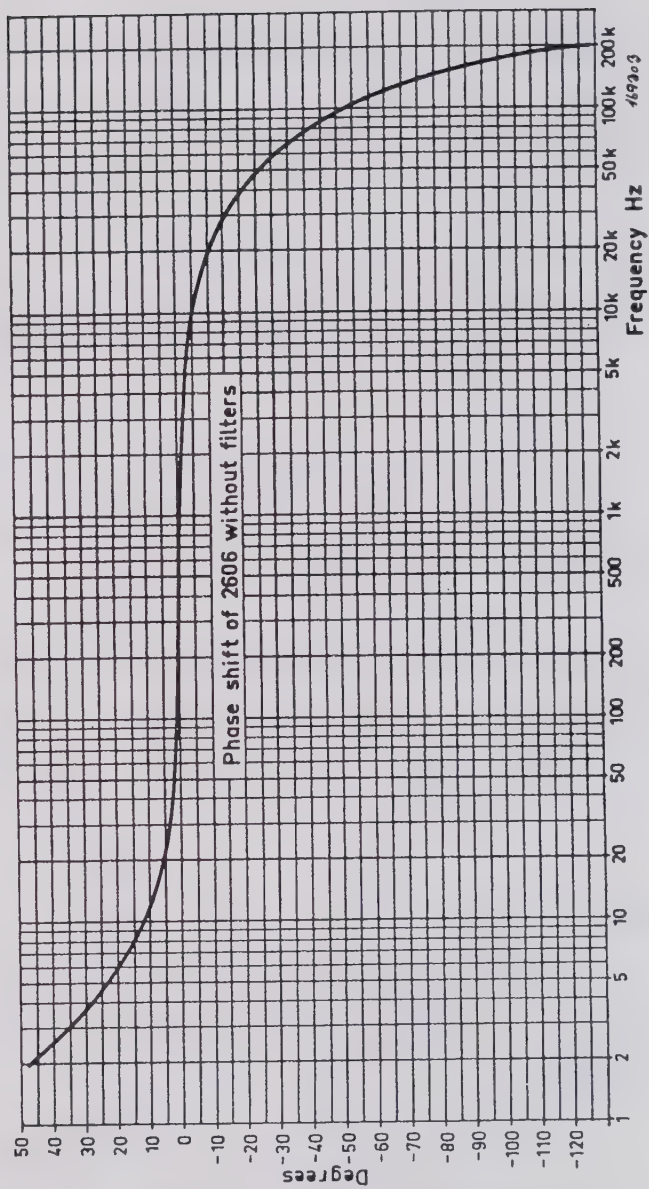


Fig.2.15. Frequency response  
Fig.2.16. Phase response without filters



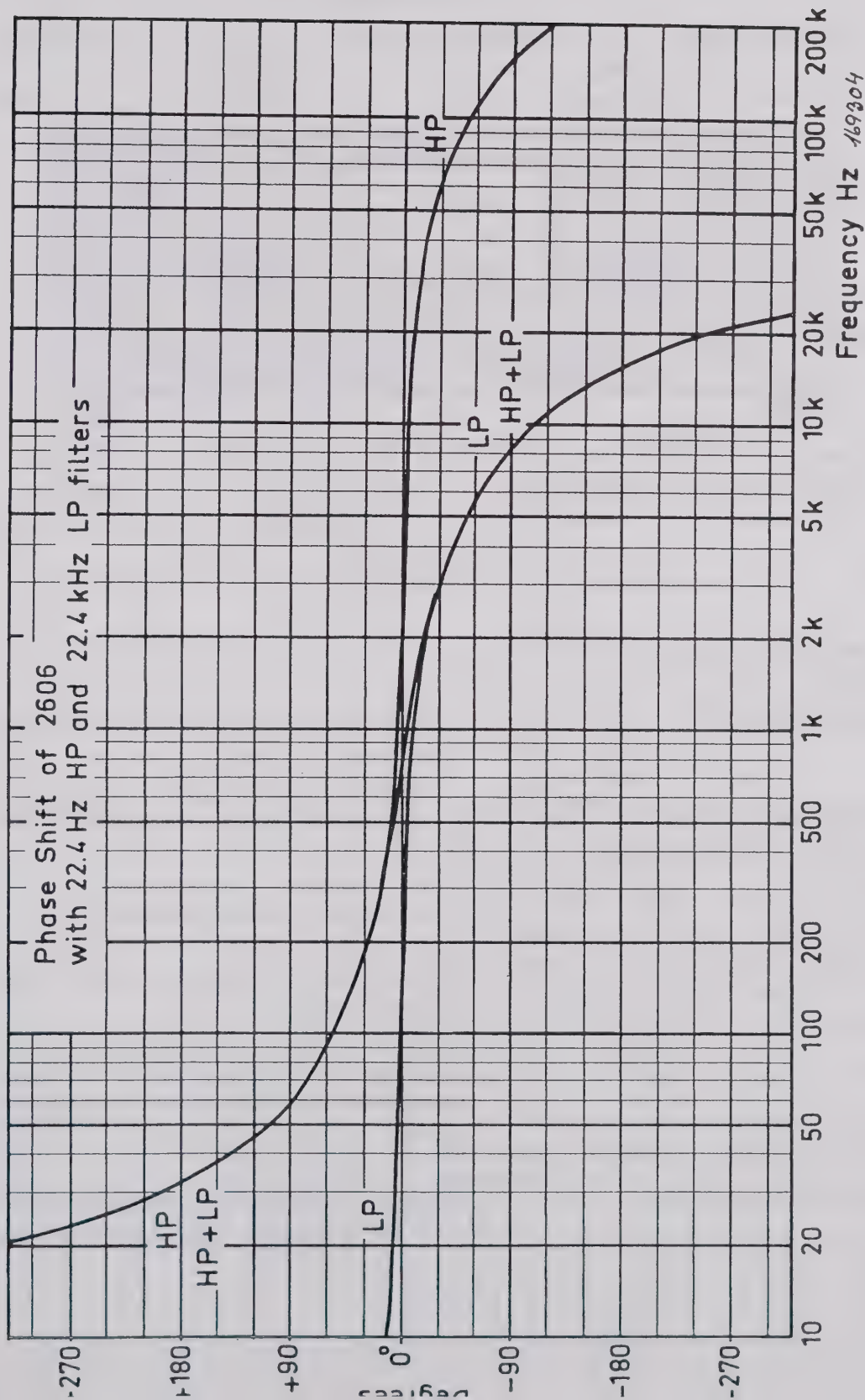


Fig.2.16. Phase response with filters

### 3. CONTROLS

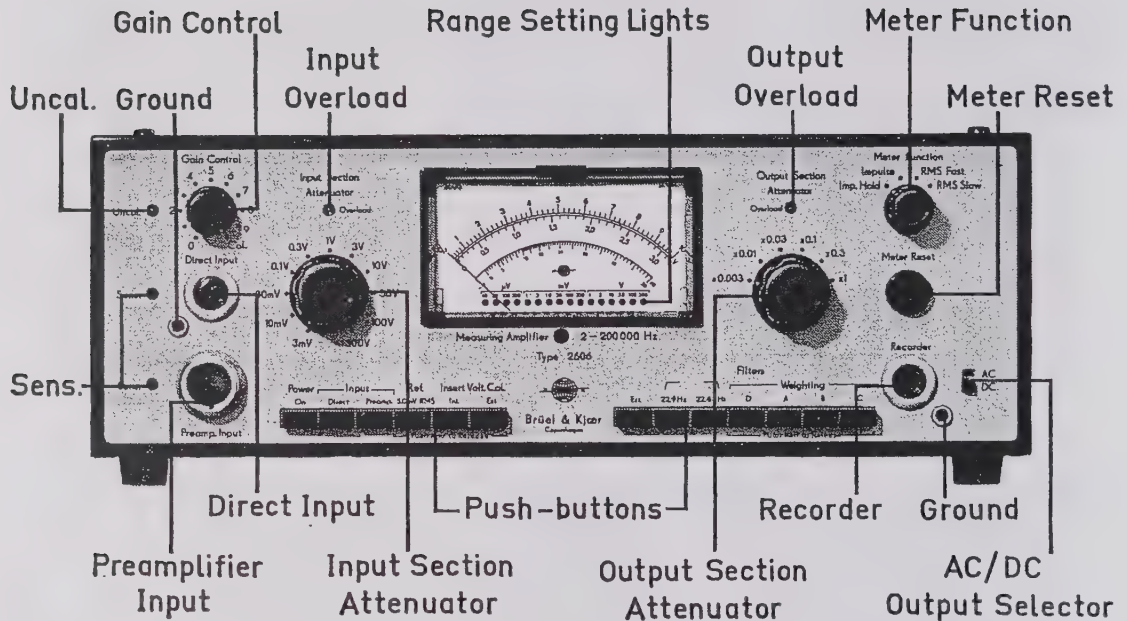


*Fig.3.1. Front panel*

## FRONT PANEL

### METER SCALE:

Tilt the glass panel forward to slide the scale out.

At the bottom of the front panel there are two rows of push—buttons. Their functions are as follows:

### POWER:

On/Off push—button for power.

### INPUT:

Direct input or input via a preamplifier may be chosen.

### REF:

Supplies the 50 mV RMS 1 kHz sine wave signal for internal calibration purposes.

### INSERT VOLT.CAL:

Choice of internal or external signal. Internal is 50 mV from the 1 kHz sine

wave generator. External is for connection of a frequency generator. The load impedance is  $1\text{ k}\Omega$ .

**EXT:**

For external filter selection. For connection of 1612 see also Overload Relay Socket.

**22.4 Hz:**

High Pass filter with cut-off frequency at 22.4 Hz. Sets upper limit of audio-frequency range.

**D, A, B, C:**

For selection of weighting networks. When none are selected the meter has a linear frequency response from 2 Hz–200 kHz.

The remaining controls and sockets on the front panel are:

**GAIN CONTROL:**

For continuous control of the gain of the first amplifier. When in position "Cal" the gain is fixed. Maximum attenuation 10–11 dB.

**INPUT SECTION ATTENUATOR:** Stepped attenuator for attenuation of the input signal. 10 dB steps. The voltages marked around the knob show the maximum input voltage (for full-scale deflection) for each knob-setting. By using the Gain Control input voltages up to 1000 V can be measured. See Voltage Measurements, Operation chapter.

**UNCAL:**

This light comes on when the Gain Control knob is not in the "Calibrated" position.

**OVERLOAD INDICATORS:**

These indicate when the input or output amplifiers are overloaded. While these lights flash the meter reading is inaccurate and probably lower than the correct value. The indicators are adjustable

|                                       |                                                                                                                                                                                                                                                                                    |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DIRECT INPUT:</b>                  | Input to the input amplifier. The input level can be adjusted by the Gain Control. Input impedance $1\text{ M}\Omega // 50\text{ pF}$ . Takes B & K coaxial plugs.                                                                                                                 |
| <b>PREAMP.INPUT:</b>                  | 7-pin plug for connection of B & K microphones via their preamplifiers. The input level can be adjusted by the Gain Control.                                                                                                                                                       |
| <b>SENS:</b>                          | Two screwdriver operated potentiometers situated by their respective inputs. They adjust the gain of the first amplifier to compensate for different transducer sensitivities. Attenuation approx. 10 dB.                                                                          |
| <b>OUTPUT SECTION<br/>ATTENUATOR.</b> | Stepped attenuator for attenuation of the signal level between filter outputs and the output amplifier. To ensure the best possible signal/noise ratio the knob should be kept as far clockwise as possible. 10 dB steps.                                                          |
| <b>METER FUNCTION:</b>                | This selects Fast and Slow meter damping according to IEC Publication 179 or Impulse characteristics according to the proposed extension to IEC Publication 179 and DIN 45 633 Part 2. In the "Imp.Hold" position the meter will hold the maximum RMS value of the applied signal. |
| <b>METER RESET:</b>                   | Discharges the meter "Hold" circuit when Impulse Hold measurements are taken.                                                                                                                                                                                                      |
| <b>RECORDER:</b>                      | Output socket for recording. AC or DC outputs are available. With DC the output impedance is $25\text{ k}\Omega$ and the maximum output is 1 V and 0.06 mA. With AC the output impedance is $50\text{ }\Omega$ and                                                                 |

1. Set knobs:

|                           |                          |
|---------------------------|--------------------------|
| GAIN CONTROL              | "Cal"                    |
| INPUT SECTION ATTENUATOR  | "At suitably high level" |
| OUTPUT SECTION ATTENUATOR | "x 1"                    |
| METER FUNCTION            | As required.             |

Select push-button:

INPUT "Direct"

Feed the unknown voltage to the Direct Input socket and adjust the INPUT ATTENUATOR until a suitable deflection is obtained. If the deflection is insufficient, even when the INPUT ATTENUATOR is in its 3 mV range, then adjust the OUTPUT ATTENUATOR.

To measure input voltages from 300–1000 V.

Use can be made of the Gain Control to accommodate voltages between 300 and 1000 V but first it must be calibrated to give exactly 10 dB attenuation.

This may be done as follows:

Output Section Attenuator

| Input Section Attenuator |       | X0.003 | X0.01 | X0.03 | X0.1 | X0.3 | X 1 |
|--------------------------|-------|--------|-------|-------|------|------|-----|
|                          | 3 mV  | 114    | 104   | 94    | 84   | 74   | 64  |
|                          | 10 mV | 104    | 94    | 84    | 74   | 64   | 54  |
|                          | 30 mV | 94     | 84    | 74    | 64   | 54   | 44  |
|                          | 0.1 V | 84     | 74    | 64    | 54   | 44   | 34  |
|                          | 0.3 V | 74     | 64    | 54    | 44   | 34   | 24  |
|                          | 1 V   | 64     | 54    | 44    | 34   | 24   | 14  |
|                          | 3 V   | 54     | 44    | 34    | 24   | 14   | 4   |
|                          | 10 V  | 44     | 34    | 24    | 14   | 4    | –6  |
|                          | 30 V  | 34     | 24    | 14    | 4    | –6   | –16 |
|                          | 100 V | 24     | 14    | 4     | –6   | –16  | –26 |
|                          | 300 V | 14     | 4     | –6    | –16  | –26  | –36 |

Fig.4.6. Amplification from input to AC Recorder socket for various attenuator settings (dB).

1. Repeat the calibration procedure for normal voltage measurements.

With the needle set on the red mark (50 mV) set the INPUT ATTENUATOR to 30 mV causing the needle to deflect off scale.

3. Adjust the GAIN CONTROL to bring the needle back to the red mark. The 2606 is then calibrated so that 10 dB must be added to the value of all meter indications.

### INSERT VOLTAGE CALIBRATION OF A MICROPHONE.

When a Cathode Follower Type 2617 is used in conjunction with the 2606, 1" microphones can be calibrated by means of the Insert Voltage Method, which is a method for determining the open circuit sensitivity of the microphone. (The open circuit sensitivity of a microphone at a given single frequency is the voltage which appears at its terminals when the microphone is working into an effectively infinite impedance).

The principle of the Insert Voltage method may be explained with reference to Fig.4.7.

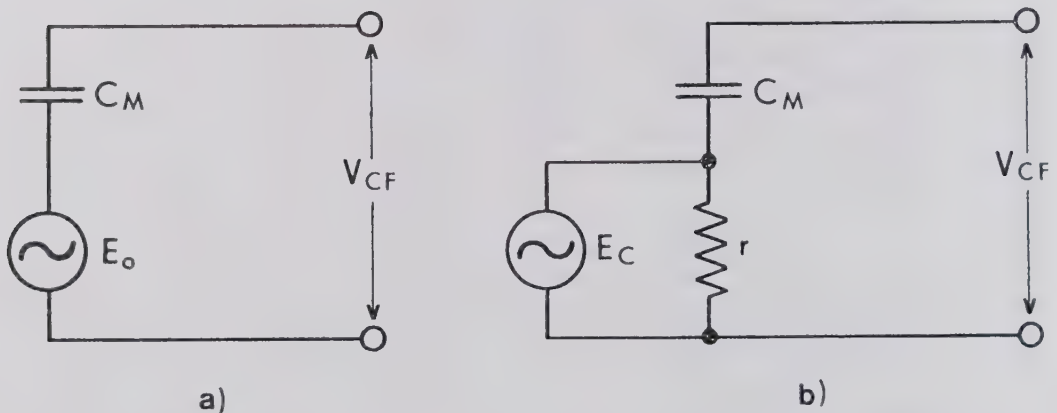


Fig.4.7. Insert voltage calibration of a microphone

The condenser microphone (capacity  $C_m$ ) is first subjected to a sound pressure level. Let the open circuit voltage produced be  $E_o$  and the voltage at the cathode follower output be  $V_{CF}$  as in a).

A small resistor is then connected in series with the microphone and a voltage  $E_C$  applied across it as in b). This insert voltage is adjusted so the

the maximum output is 50 V (peak) and 10 mA. The minimum load impedance should be  $5\text{ k}\Omega$ , (AC).

**AC/DC:**

Selects AC or DC output from the Recorder socket.

## REAR PANEL

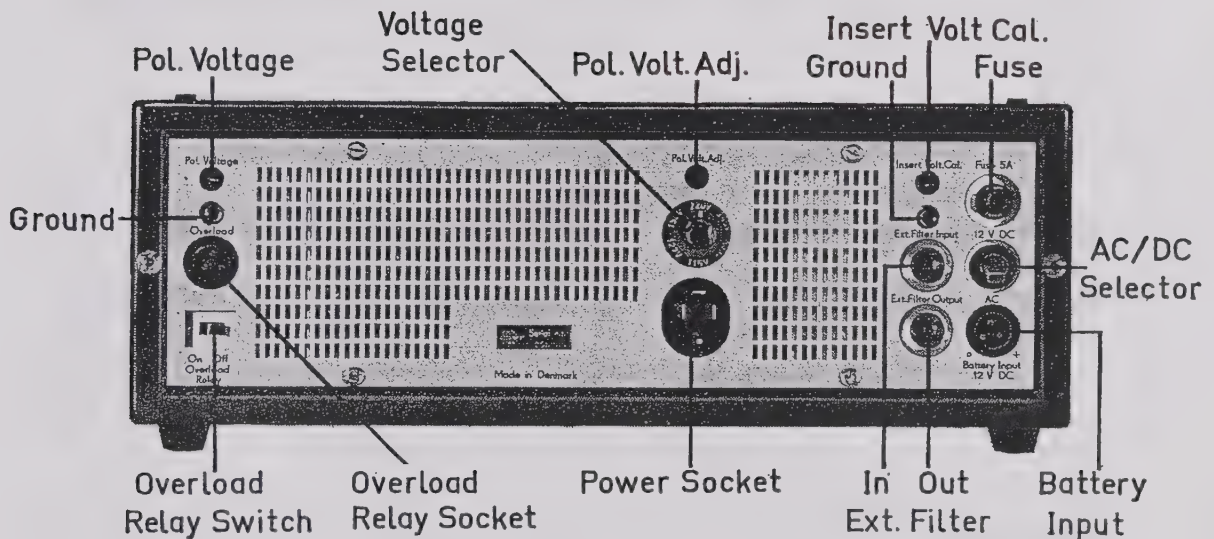


*Fig.3.2. Rear panel*

**POL.VOLTAGE:**

Socket for measurement of polarization voltage with an external voltmeter. A DC voltmeter having a rating of at least  $20,000\ \Omega/\text{volt}$  should be used. A ground return socket is placed below.

N.B. Chassis ground should not be used when checking the polarization voltage.

**POL.VOLT.ADJ:**

Screwdriver adjustable potentiometer for setting microphone polarization voltage.

**OVERLOAD:**

Output socket from overload relay.

The two bottom pins are the relay connections. The top pin gives + 20 V to supply a 1612 Filter Set with the nega-

tive return through the External Filter socket.

The plug needed for the socket is JP 4701.

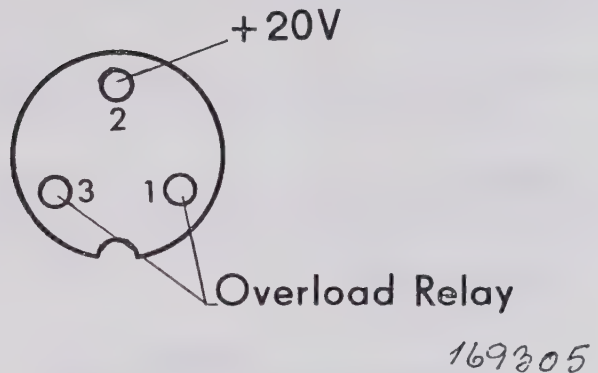


*Fig.3.3. Overload relay socket*

**OVERLOAD RELAY SWITCH:**

On/Off switch for overload relay.

**VOLTAGE SELECTOR:**

For selection of correct mains supply voltage. To turn the switch it is necessary to unscrew the central fuse and then a wide bladed screwdriver or small coin may be used.

**POWER SOCKET:**

The horizontally opposed pins are the "live" ones and a plug and cable are supplied to fit them (AN 0005) The pins at the top and bottom are both connected to the transformer shield which then may be connected to either the chassis ground or the signal ground.

**INSERT VOLT.CAL:**

Socket for input signal from external generator. Input impedance  $1\text{ k}\Omega$ . Ground socket below.

**EXT.FILTER  
INPUT/OUTPUT:**

These sockets take the standard B & K coaxial plugs and are for connection of an external filter.

The input impedance of the External Filter Output is  $146\text{ k}\Omega$ . The output impedance of the External Filter Input is very low ( $<10\Omega$ ) and must be loaded by not less than  $500\Omega$ . Max. output voltage is 5 V peak.

**FUSE 5 A:**

5 Amp. fuse for 12 V DC supply.

**AC/DC SELECTOR:**

Switch to select AC or DC power supply.

**BATTERY INPUT:**

3 pin socket for 12 V DC supply.  
The third (upper) pin is not used for anything. B & K plug Type JP 4701.

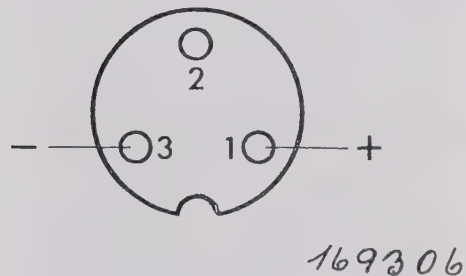


*Fig.3.4. Battery socket*

## **4. OPERATION**

### **PRELIMINARY ADJUSTMENTS**

Before the instrument is used the following adjustments should be made:

1. With any meter scale, set the needle deflection to zero by using the mechanical adjuster under the meter scale.
2. Select "AC" or "DC" operation with the switch at the rear panel.

If an AC power supply is used check the voltage selector is set to the correct line voltage. If not remove the central fuse and adjust with a small coin or screwdriver.

If DC is used,  $12\text{ V} \pm 10\%$  and approx. 2 amp. is necessary. It should be noted that with DC operation the scale lamps are not lit (saving 6 Watts). The range indicator lights still operate and show when the instrument is on.

The above adjustments are usually sufficient for everyday use. The following ones should need carrying out rather less frequently.

#### **Measurement of microphone polarization voltage.**

The measurement should be carried out with a DC voltmeter having a rating of at least 20.000 ohms/volt. The voltage can be adjusted by means of the screwdriver potentiometer on the back panel.

#### **Adjustment of overload indicators.**

The input overload indicator should operate at 5.6 V peak and the output overload indicator at 56 V peak. Their operation may be checked as follows using the voltage scale.

For the Input Overload Indicator:

1. Select Reference signal  
Set Input Attenuator to 0.1 V  
Set Output Attenuator to x 1
2. With Gain Control reduce scale deflection to 40 mV (RMS)
3. Set Input Attenuator to 10 mV. The overload indicator should just operate. If not, remove printed circuit board ZH 0011 and adjust the potentiometer indicated in Fig.4.1a.

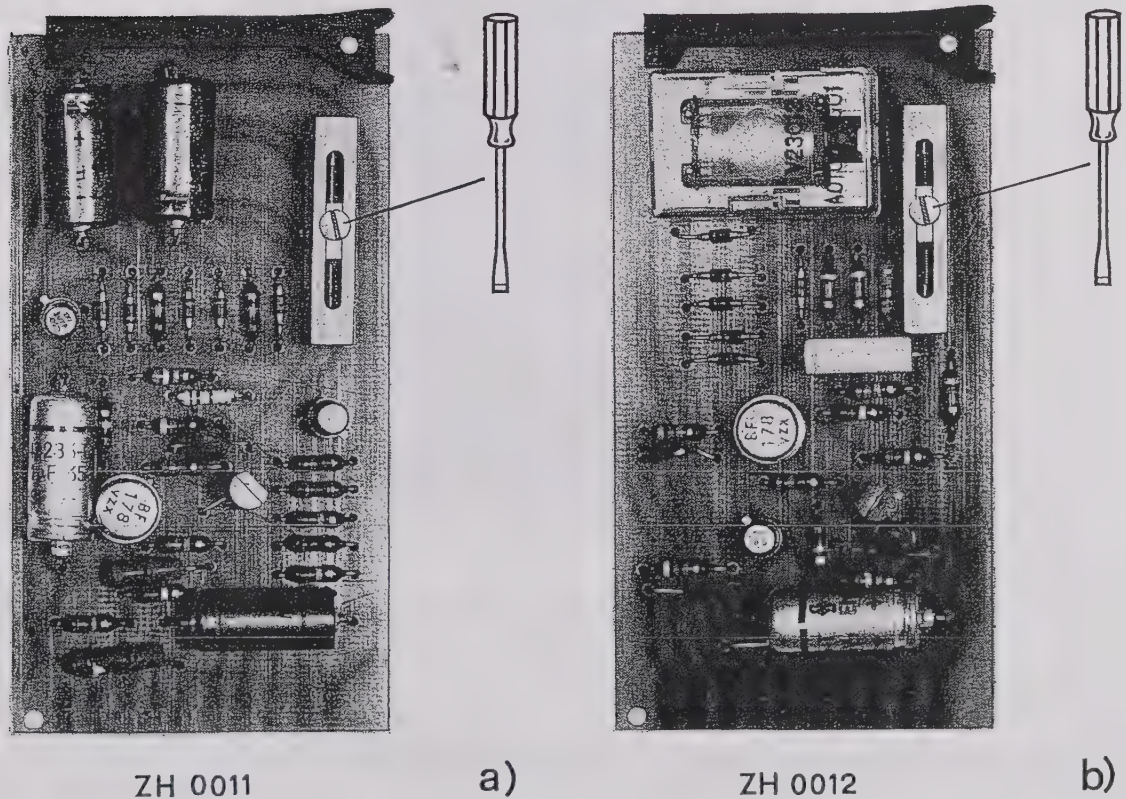


*Fig.4.1. Adjustment of overload indicators*

For the Output Overload Indicator:

1. Select Reference signal  
Set Input Attenuator to 30 mV  
Set Output Attenuator to x 1

2. With Gain Control set scale deflection to 22 mV.
3. Set Output Attenuator to  $\times 0.1$ . The overload indicator should just operate. If not remove printed circuit board ZH 0012 and adjust the potentiometer indicated in Fig.4.1b.

### **Selection of signal ground or chassis ground.**

Choice of signal ground or chassis ground is available to suit the requirements of the particular set-up.

The connections are made with a small screw-held plate which is situated on the main circuit board on the underside of the apparatus. See Fig.4.2.

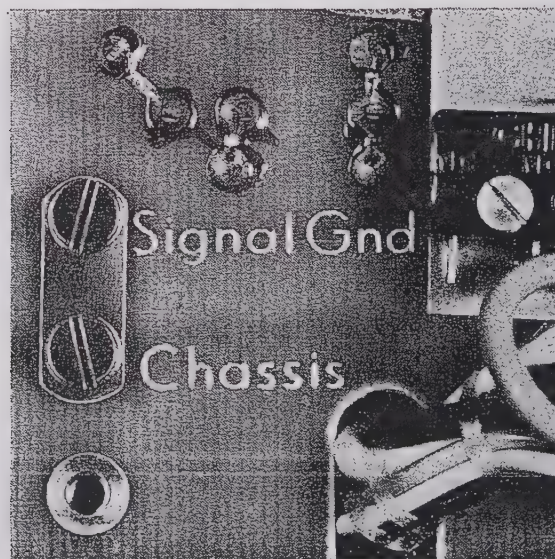


*Fig.4.2. Selection of signal ground or chassis ground*

### **CALIBRATION FOR SOUND MEASUREMENTS.**

#### **Using Pistonphone or Sound Level Calibrator**

1. Carry out the preliminary adjustments, if necessary.

| Microphone Open Circuit Sensitivity                                 | B & K Microphone Type  | Scale No. |
|---------------------------------------------------------------------|------------------------|-----------|
| 26 — 90 mV per N/m <sup>2</sup><br>(2.6 — 9 mV per $\mu$ bar)       | 4131 4132<br>4144 4145 | SA 0039   |
| 2.6 — 10 mV per N/m <sup>2</sup><br>(0.26 — 1.0 mV per $\mu$ bar)   | 4133 4134              | SA 0040   |
| 0.8 — 2.6 mV per N/m <sup>2</sup><br>(0.08 — 0.26 mV per $\mu$ bar) | 4135 4136              | SA 0061   |
| 0.4 — 1.6 mV per N/m <sup>2</sup><br>(0.04 — 0.16 mV per $\mu$ bar) | 4138                   | SA 0073   |

*Fig.4.3. Microphone scales for 2606.*

- Fit the meter scale appropriate to the sensitivity of the microphone being used. See Fig.4.3.
- Fit the microphone and associated preamplifier.
- Set knobs:

GAIN CONTROL

INPUT SECTION ATTENUATOR

OUTPUT SECTION ATTENUATOR

METER FUNCTION

"Cal"

At suitably high level.

"x 1"

"RMS Fast"

5. Select push—button:

INPUT Preamp. for condenser microphone  
INPUT Direct for piezoelectric microphone

Do not select any weighting network.  
Switch on and allow 30 sec. to warm up.

6. Using a Pistonphone 4220 or Sound Level Calibrator 4230 the meter should read 124 or 94 dB respectively. If it does not, adjust the sensitivity potentiometer beside the input socket that is being used, until the correct deflection is obtained.

**Using the built—in reference voltage**

1. Carry out the preliminary adjustments, if necessary.
2. Fit the meter scale appropriate to the sensitivity of the microphone being used. See Fig.4.3.
3. Fit the microphone and associated preamplifier.  
Any microphone accessories can remain in position.
4. Set knobs:

|                           |               |
|---------------------------|---------------|
| GAIN CONTROL              | "Cal"         |
| INPUT SECTION ATTENUATOR  | 0.1 V (90 dB) |
| OUTPUT SECTION ATTENUATOR | "x 1"         |
| METER FUNCTION            | "RMS Fast"    |

5. Select push—buttons:

"Ref"  
INPUT Preamp. for condenser microphones  
INPUT Direct for piezoelectric microphone  
Switch on.

7. From the calibration chart of the microphone in use, determine its Open Circuit Sensitivity in mV per N/m<sup>2</sup>.
6. Using a small screwdriver adjust the sensitivity potentiometer beside the input socket that is being used, until the required open circuit

sensitivity is indicated on the meter scale marked Open Circuit Sensitivity.

## MEASUREMENT OF SOUND.

Sound measurements may be made as follows:

1. Calibrate the meter and microphone as described above.
2. Hold the microphone steadily and at least 1 m. away from the body or set it up on a tripod or other support that won't interfere with the sound field.
3. Select the weighting network to be used.
4. Keeping the OUTPUT SECTION ATTENUATOR in the "x 1" position as much as possible, adjust the INPUT SECTION ATTENUATOR to obtain a suitable deflection without overload.

If the INPUT OVERLOAD lamp flashes turn the INPUT SECTION ATTENUATOR up.

If the OUTPUT OVERLOAD lamp flashes turn the OUTPUT SECTION ATTENUATOR up.

5. The measured Sound Level or Sound Pressure Level is the sum of the meter reading and the attenuator setting displayed by the indicator lamp on the meter scale.

In reporting sound levels it should always be stated which weighting network has been used e.g. 60 dB (A), 60 dB (D) or for impulse measurements 60 dB (AI).

The maximum SPL's that can be measured accurately with 1" and 1/2" microphones with respect to the crest factor of the signal can be seen in Fig.4.4.

For further information on sound measurements our booklet "Acoustic Noise Measurements" is available on request.

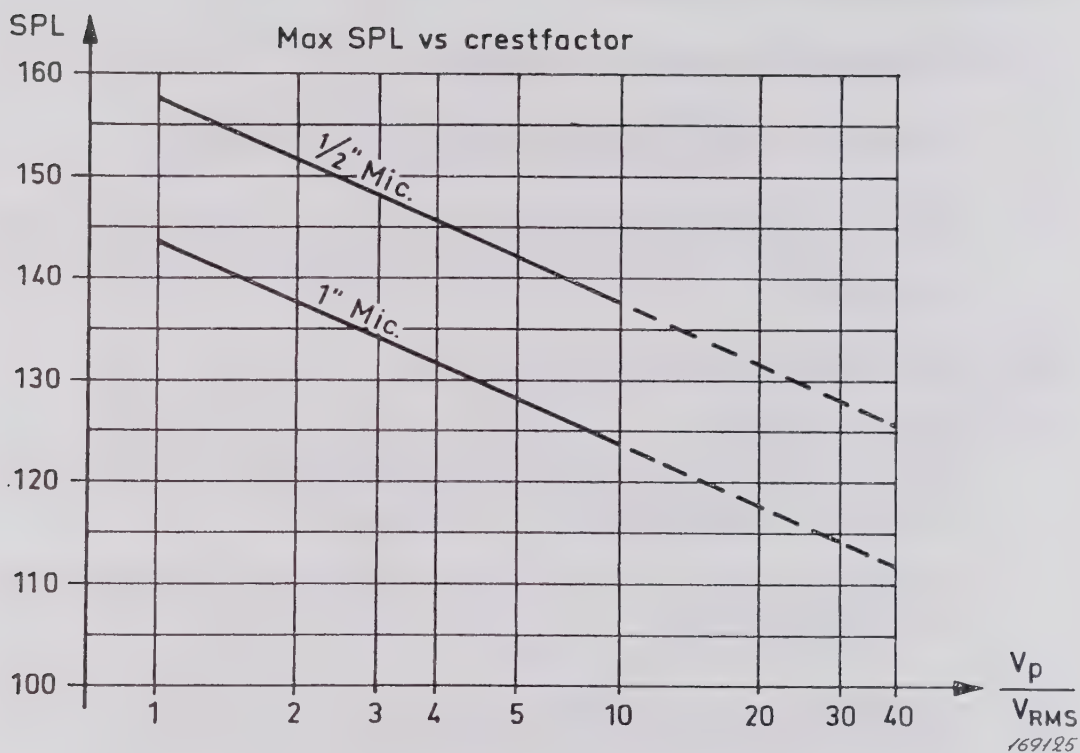


Fig.4.4. Maximum SPL's that can be measured accurately with 1" and 1/2" microphones with respect to crestfactor of signal.

| Accelerometer<br>Sensitivity mV/g | B & K<br>Accelerometer Type | Scale No. |
|-----------------------------------|-----------------------------|-----------|
| 1.7 — 6                           | 4344                        | SA 0074   |
| 6 — 17                            | 4339 4343<br>4333 4335 4340 | SA 0071   |
| 17 — 60                           | 4332 4334                   | SA 0070   |
| 60 — 170                          | 4338                        | SA 0075   |

Fig.4.5. Accelerometer scales for 2606

## CALIBRATION FOR VIBRATION MEASUREMENTS.

### Using Vibration Calibrator 4291

1. Carry out the preliminary adjustments, if necessary.
2. Fit the meter scale appropriate to the sensitivity of the accelerometer being used. See Fig.4.5.
3. Fit the accelerometer and associated preamplifier.
4. Set knobs:

|                           |            |
|---------------------------|------------|
| GAIN CONTROL              | "Cal"      |
| INPUT SECTION ATTENUATOR  | "3 g"      |
| OUTPUT SECTION ATTENUATOR | "x 1"      |
| METER FUNCTION            | "RMS Fast" |
5. Select push-button INPUT "Preamp" or INPUT "Direct" according to requirement. Switch on and allow 30 sec. to warm up. Do not select any weighting networks.
6. Using the Acceleration Calibrator 4291 vibrate the accelerometer at 1 g peak.
7. With a screwdriver adjust the sensitivity potentiometer beside the input socket that is being used, until a deflection of 0.71 g RMS is obtained on the meter scale.

## MEASUREMENT OF VIBRATION

Vibration measurements may be made as follows:

1. Calibrate the meter as described above.
2. Mount the accelerometer by one of the methods described in its instruction manual, taking care to avoid cable whip.
3. Keep the 2606 as far away as possible from the vibration environment and any other unrequired influences.

Keeping the OUTPUT SECTION ATTENUATOR in the "x 1" position as far as possible, adjust the INPUT SECTION ATTENUATOR to obtain a suitable deflection without overload.

If the INPUT OVERLOAD lamp flashes turn up the INPUT SECTION ATTENUATOR knob.

If the OUTPUT OVERLOAD lamp flashes turn the OUTPUT SECTION ATTENUATOR up.

For further information on vibration measurements our booklet "Mechanical Vibrations and Shock Measurements" is available on request.

## CALIBRATION FOR VOLTAGE MEASUREMENTS

1. Carry out the preliminary set up above, if necessary.
2. Fit voltage scale.
3. Set knobs:

|                          |                   |
|--------------------------|-------------------|
| GAIN CONTROL             | "Cal"             |
| INPUT SECTION ATTENUATOR | "0.1 V." (100 mV) |
| METER FUNCTION           | "RMS Fast"        |

Select push-buttons:

REF.  
INPUT Direct  
Do not select any filter.

The needle should now deflect to the red mark on the scale (i.e. indicate 50 mV). If it does not, adjust the sensitivity adjustment beside the DIRECT INPUT socket.

## VOLTAGE MEASUREMENTS

Voltage measurements may be made as follows:

voltage from the cathode follower is  $V_{CF}$  as before. Then  $E_o = E_c$  and the open circuit voltage can be calculated from:

$$\text{Open Circuit Sensitivity} = \frac{E_c}{\text{sound pressure.}}$$

When the 2617 is used with the 2606 the insert voltage  $E_c$  can be supplied in two ways. The internal reference oscillator can be used to give a voltage at a fixed frequency of 1000 Hz or an external generator such as the Beat Frequency Oscillator 1022, can be used to give a signal at any other required frequency. With the internal reference oscillator a Sound Level Calibrator 4230 (frequency 1000 Hz) is an ideal sound source and with an external generator the Pistonphone 4220 (frequency 250 Hz) can also be used.

The procedures are as follows:

#### Using the Internal Reference Oscillator.

1. Connect the 2617 to the "Preamp" input and fit the microphone.
2. Apply the Sound Level Calibrator 4230 to the microphone and note the voltage produced from the cathode follower,  $V_{CF}$ .
3. Remove the sound source. Depress the push-buttons "Ref" and "Int. Insert Volt Cal." and adjust the "Gain Control" until  $V_{CF}$  is the same as before.
4. When this occurs the calibration voltage,  $E_c$ , from the reference oscillator is equivalent to the open circuit voltage of the microphone  $E_o$ . To measure the calibration voltage release the "Int. Insert Volt Cal." button and read it from the meter without readjusting the "Gain Control". Then:

$$\text{Open Circuit Sensitivity} = \frac{E_c}{\text{sound pressure.}}$$

N.B. The sound level calibrator produces a sound pressure of

$$94 \text{ dB} = 2 \times 10^{-5} \times 10^{\frac{94}{20}} = 1 \text{ N/m}^2 \text{ ( or } 10 \text{ } \mu\text{bar )}$$

### Using an External Generator.

1. Connect the external generator to the Insert Volt. Cal. socket on the rear panel of the 2606 (The input impedance is  $1\text{ k}\Omega$ ).
2. Connect the 2617 to the "Preamp" input and fit the microphone.
3. Apply the sound source to the microphone and note the voltage produced from the cathode follower  $V_{CF}$ .
4. Remove the sound source. Adjust the frequency of the external generator to be the same as that of the sound source. Depress the push-button "Ext. Insert Volt. Cal." and adjust the output from the generator until  $V_{CF}$  is the same as before.
5. When this occurs the calibration voltage,  $E_c$ , is equivalent to the open circuit voltage of the microphone  $E_o$ . To measure the calibration voltage, remove the plug from the Insert. Volt. Cal. socket and connect it to the "Direct" input socket, without readjusting the output voltage. Then:

$$\text{Open Circuit Sensitivity} = \frac{E_c}{\text{sound pressure.}}$$

N.B. If the Pistonphone is used it produces a sound pressure at 250 Hz of

$$124\text{ dB} = 2 \times 10^{-5} \times 10^{\frac{124}{20}} = 31.6\text{ N/m}^2 \text{ (or } 316\text{ }\mu\text{bar)}$$

## **5. ACCESSORIES**

The combinations of accessories that can be used with the 2606 can be seen in Figs.5.1. and 5.2. The specifications of these accessories can be found in the B & K Short and Main Catalogues which are available through your B & K Agent.

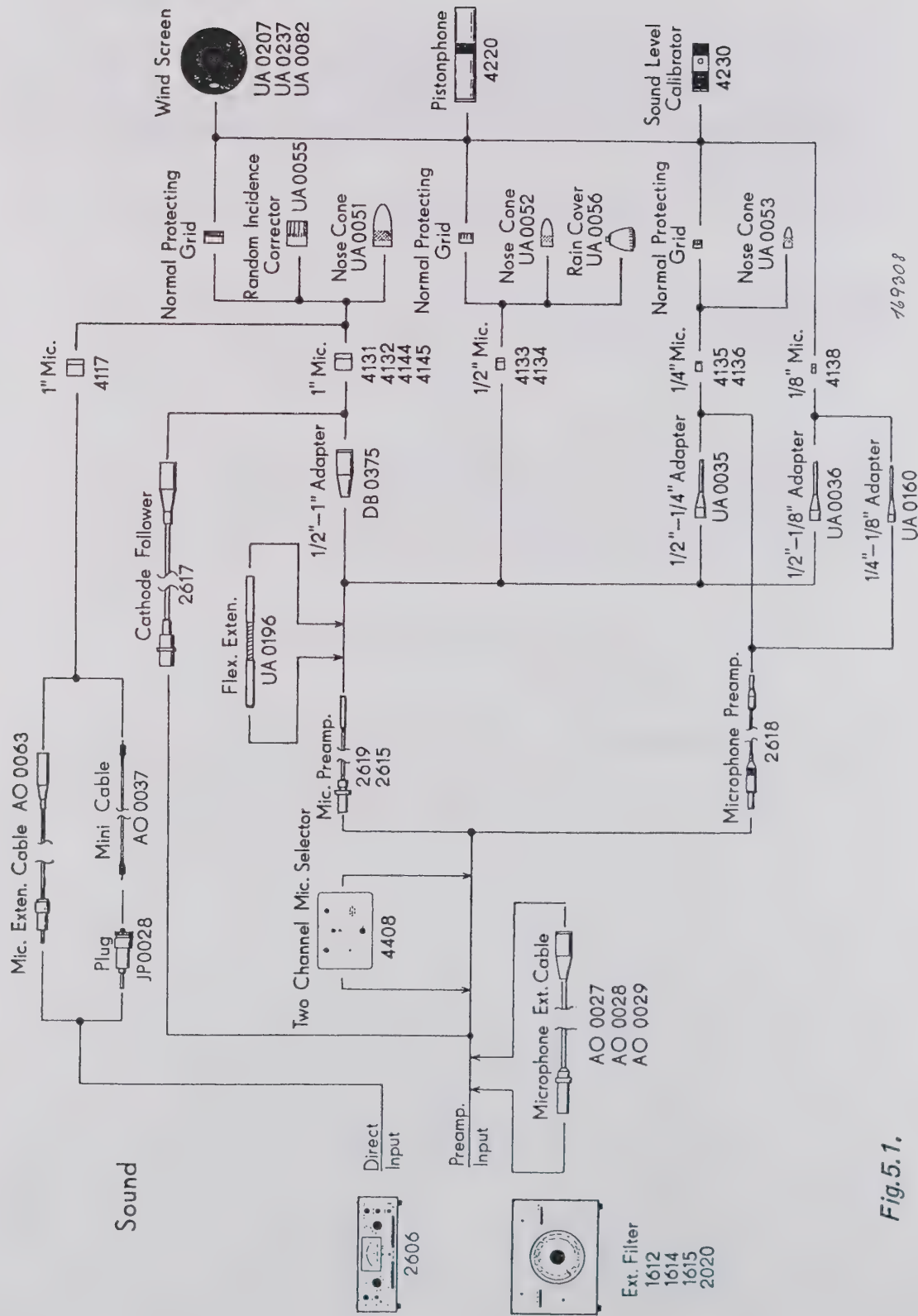


Fig. 5.1.

169303

# Vibration

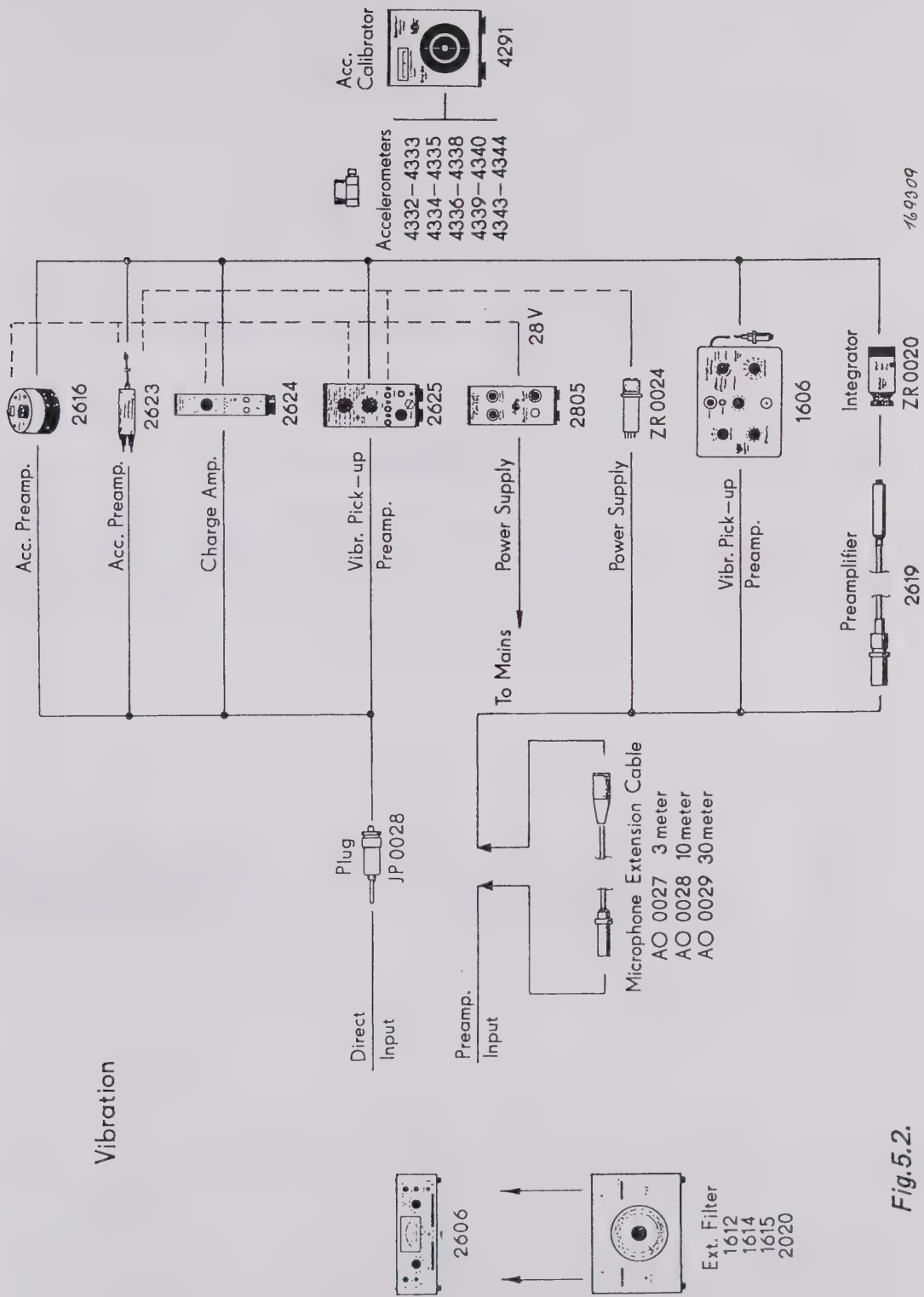


Fig.5.2.

169809

## 6. USE WITH OTHER INSTRUMENTS

### RECORDING WITH THE LEVEL RECORDER 2305

In many cases the noise or vibration level will vary with time. If a study of this variation is to be made a recording will be needed. Here the Level Recorder 2305 will be useful. A set up can be seen in Fig.6.1. and the controls of the Level Recorder in Fig.6.2.

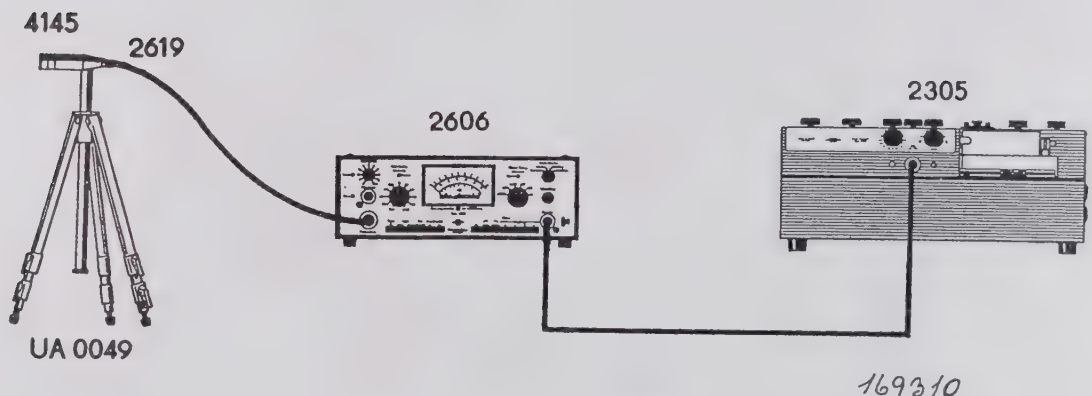


*Fig.6.1. Set up for recording sound*

### AC recording

AC recording should be used for the recording of continuous signals. The 2606 has an amplification range of over 75 dB from input to AC recorder output so a 75 dB potentiometer can be used in the Level Recorder as well as 10, 25, 50 dB and linear potentiometers.

The procedure for setting up the recording system is shown in here with reference to a 50 dB potentiometer, but a similar procedure is used for the other potentiometers.

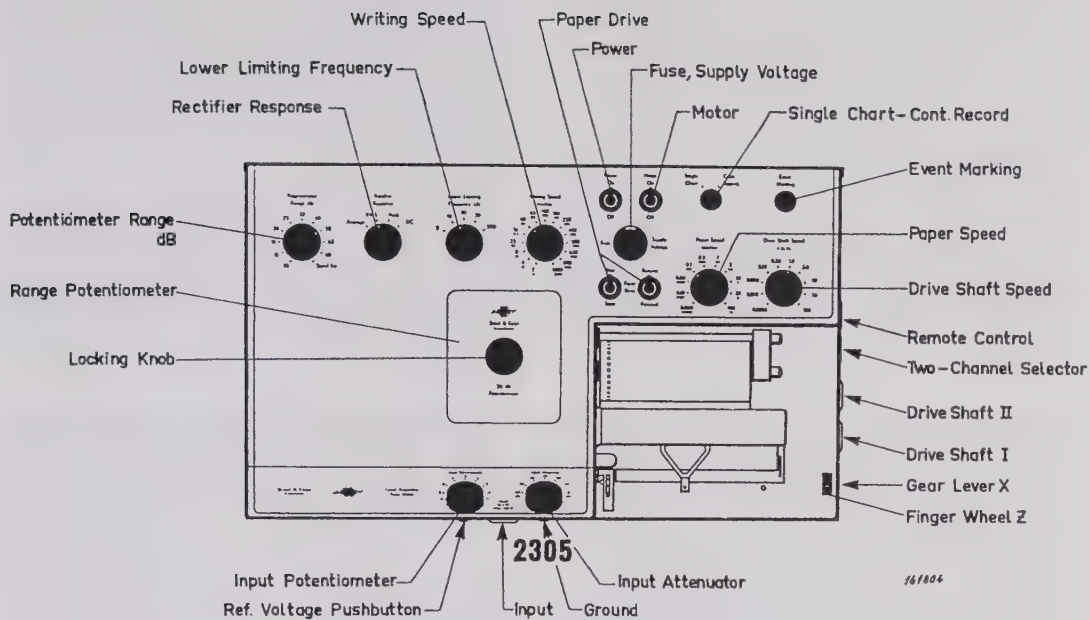


*Fig.6.2. Level Recorder 2305*

1. Set the control knobs on the Level Recorder to:

|                     |                |
|---------------------|----------------|
| POTENTIOMETER RANGE | "50"           |
| RECTIFIER RESPONSE  | "RMS"          |
| LOWER LIM. FREQ.    | as required    |
| WRITING SPEED       | "100 (200)"    |
| PAPER SPEED         | suitable value |
| PAPER DRIVE         | "Start"        |
|                     | "Forward"      |
| POWER               | "On"           |
| MOTOR               | "On"           |

2. The deflection of the pen can now be adjusted by means of the INPUT POTENTIOMETER and the INPUT ATTENUATOR of the 2305.
3. The 2305 must be adjusted so that its pen deflection is equal to the deflection of the needle on the meter of the 2606. To do this, set up the 2606 as described under the various sections for calibration for sound, vibration or voltage as in Chapter 4.

### *Sound.*

With a pistonphone (124 dB) or sound level calibrator (94 dB) the pen should be adjusted to 4 dB above one of the thick lines on the recording paper (Fig.6.3.). The thick line then corresponds to 120 or 90 dB respectively.

With the built in reference source, once the meter deflection has been set to the correct position on the microphone open circuit sensitivity scale, the corresponding deflection on the dB scale should be noted and the pen set to this value on the paper.

e.g. Say the microphone has an open circuit sensitivity of 40 mV per N/m<sup>2</sup>. 40 on the open circuit sensitivity scale corresponds to nearly 6 dB on the dB scale. The pen should be set to 6 dB above a thick line on the paper (Fig.6.3.). The thick line will then correspond to a SPL of 90 dB (The instrument is made for microphones with a nominal sensitivity of 50 mV per N/m<sup>2</sup> = 94 dB SPL).

### *Vibration.*

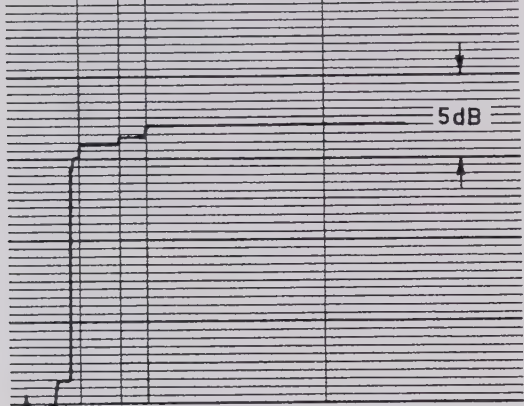
When the Accelerometer Calibrator 4291 is used, 0.71 g RMS corresponds to 17 dB on the dB scale (of scale SA 0041) or 3 dB below full scale. The pen should be set to 3 dB below a thick line on the paper. (Fig.6.3.). The thick line will then correspond to an acceleration level of 1 g RMS.

### *Voltage.*

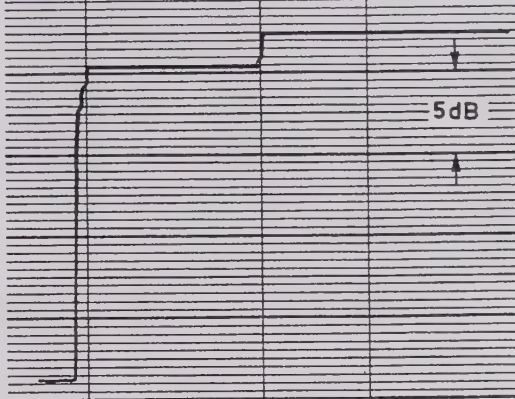
With the built in reference voltage, 50 mV corresponds to 14 dB on the dB scale (of scale SA 0037) so set the pen to 4 dB above a thick line on the paper (Fig.6.3). The thick line will then correspond to 31.6 mV.

4. Start the recording by pressing the push-button SINGLE CHART—CONT. RECORDING and turning clockwise to "Continuous Recording".
5. Release the above mentioned button to stop the recording.

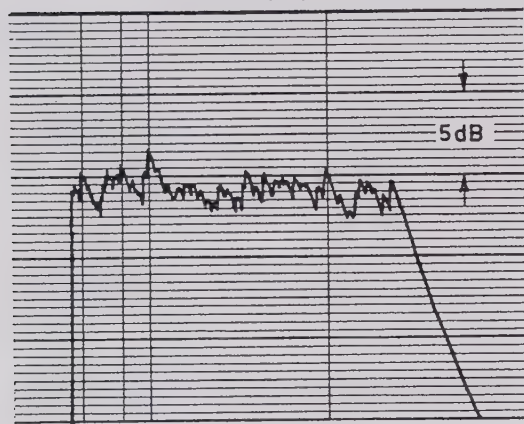
For further details on recording, the instruction manual of the Level Recorder 2305 should be consulted.



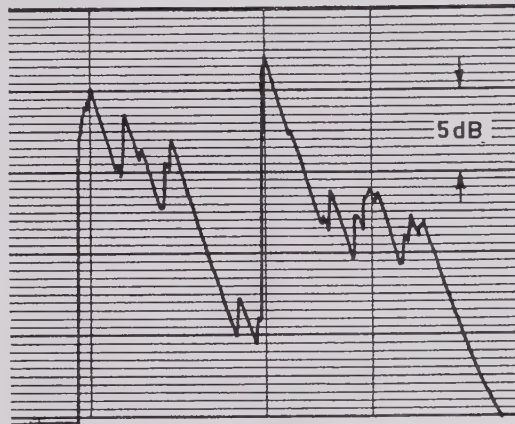
"Hold"



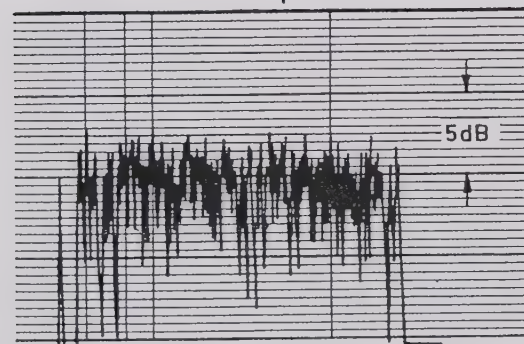
"Hold"



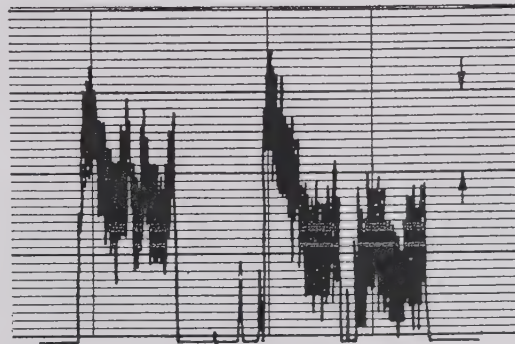
"Impulse"



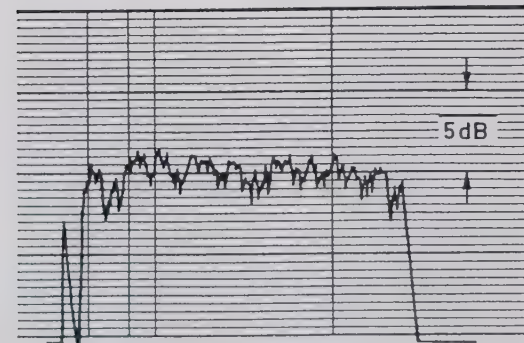
"Impulse"



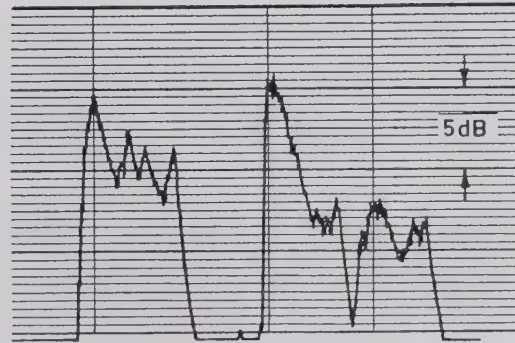
"Fast"



"Fast"



"Slow"



"Slow"

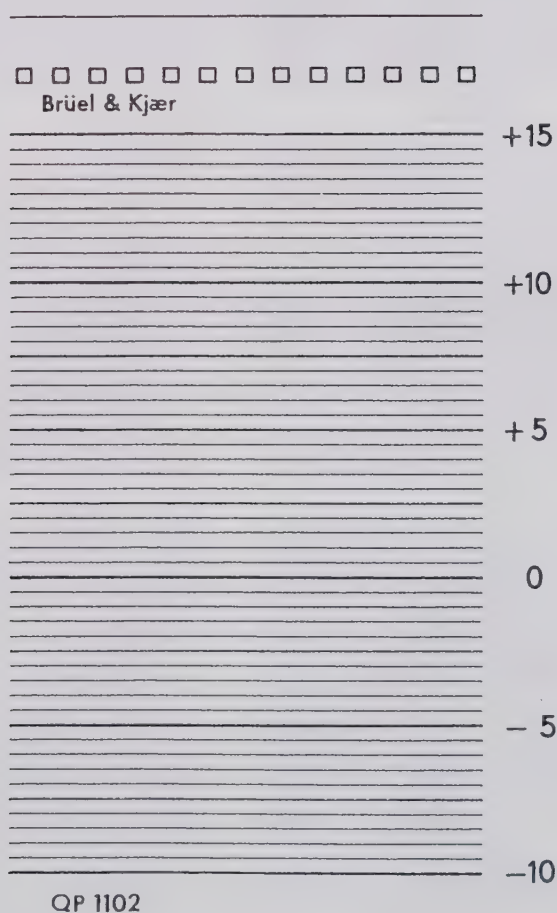
16924P

Fig.6.3. Recordings with Slow, Fast and Impulse response

## DC recording

Typewriter, teleprinter and similar noise cannot be regarded as continuous noise. If a recording is made from the AC output with "Fast" or "Slow" meter response the recording will be found to fluctuate too much. The "Impulse" response position should be used for these and the more obviously impulsive noises and the recording made from the DC output. See Fig.6.3.

The 2305 must be adjusted so the deflection on the paper (Fig.6.4.) is equivalent to the reading on the meter of the 2606.



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*Fig.6.4.*

The adjustment is made as follows:

With the 2606 set to "Ref" adjust the sensitivity adjustment beside the Preamplifier Input until the meter reads the microphone's open circuit sensitivity. With this same pointer deflection read off the dB reading on the dB scale. Adjust the input potentiometer of the 2305 until the pen has an equivalent deflection. DC output voltages of up to 5 dB above the meter scale range can be accurately measured, but the permissible crest factor of the measured signal will be reduced accordingly. See Fig.2.9.

When impulse sound levels are measured a 25 dB potentiometer should be used and the following adjustments be made:

|                      |             |
|----------------------|-------------|
| Potentiometer Range  | 25 dB       |
| Rectifier            | DC          |
| Lower Limiting Freq. | 50 Hz       |
| Writing Speed        | 315 mm/sec. |

The paper to be used is QP 1102.

## USE OF OVERLOAD RELAY WITH LEVEL RECORDER 2305.

When a graphic recording is made from the 2606, any overloading of its amplifiers can be automatically noted on the recording paper so avoiding mistakes in the interpretation of the results.

The overload relay can be used to control the Pen Lift or the Event Marking Pen of the Level Recorder to stop the recording. To operate the Pen Lift, pins 1 and 3 of the overload relay socket should be connected to pins 4 and 6 of the remote control socket of the Level Recorder.

To operate the Event Marker, pins 1 and 3 of the overload relay socket should be connected to pins 5 and 6 of the remote control socket of the Level Recorder.

To stop the recording, pins 1 and 3 of the overload relay socket should be connected to pins 6 and 7 of the remote control socket of the Level Recorder.

The various connections of the 7-poled Remote Control socket of the Level Recorder can be seen in Fig.6.5.. For further information the instruction manual of the Level Recorder should be consulted.

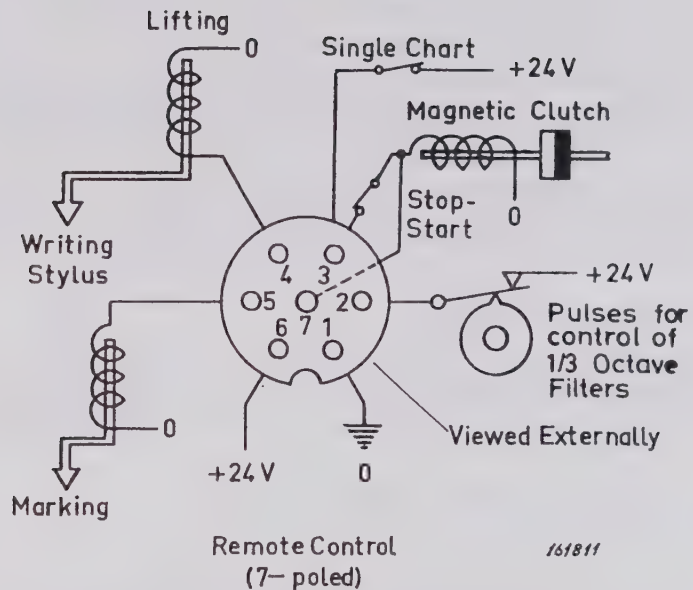


*Fig.6.5. Connections of Remote Control socket of 2305*

## TAPE RECORDING.

The tape recorder is very useful in sound and vibration measurements. Its principal applications are:

- a) Repetition of transient signals for frequency analysis.
- b) Data collection and storage for later analysis.
- c) Frequency transformation.

In all these applications the 2606 provides a high quality input to the recorder and it becomes especially valuable for field measurements when operated with a battery operated tape recorder.

The Recorder socket of the 2606 should be set to AC and the tape recorder input should have an impedance of not less than 5 k $\Omega$ . The output voltage from the 2606 that will give full scale deflection at any attenuator position is 5 Volts RMS (sine). For a tape recorder which requires a recording level considerably less than 5 V, an attenuator such as that shown in Fig.6.6. will give a better signal to noise ratio than if the output attenuator of the 2606 were used. If a tape recorder such as the B & K 7001 is used, it's input attenuator may of course be used.

Before and after the recording, reliable reference signals should be recorded. For sound signals, the Pistonphone 4220 or the Sound Level Calibrator 4230 are ideal.

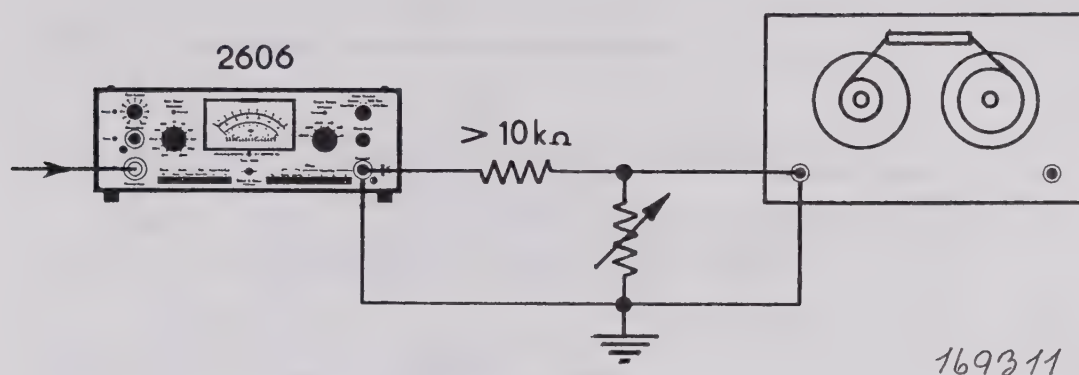


*Fig.6.6. Attenuation of 2606 output to a tape recorder*

## FREQUENCY ANALYSIS.

The Filter Sets 1612, 1614 and 1615 can all be used with the 2606 and enable 1/3 octave analyses of the signal to be made.

The 1614 has a 1/3 octave centre frequency range from 2 Hz to 160 kHz so covers the entire frequency range of the 2606. Connection of filter sets is shown in Fig.6.7. The 1614/15 sets may be connected either at the front or the back. For further information on the operation of the filter sets consult their respective instruction manuals.

## MEASUREMENT OF ACOUSTIC ABSORPTION COEFFICIENTS.

The 2606 can be used as the measuring meter for a standing wave apparatus such as the Type 4002 in Fig.6.8.

A special scale (SA 0045) for the direct reading of the percentage absorption coefficient is available to fit the 2606. It has 3 ranges, 0–100%, 0–70% and 0–30%.

To take a reading the microphone must be first placed at a position of maximum sound pressure and the deflection of the meter adjusted to full scale (100%) by means of the "Gain Control". The microphone is then

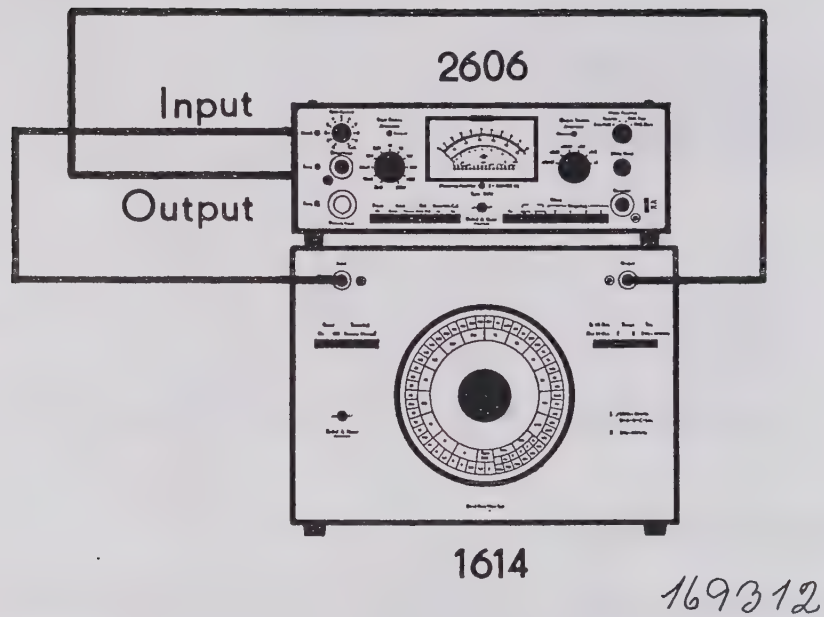


Fig.6.7. Connection of 2606 to Filter Set 1614

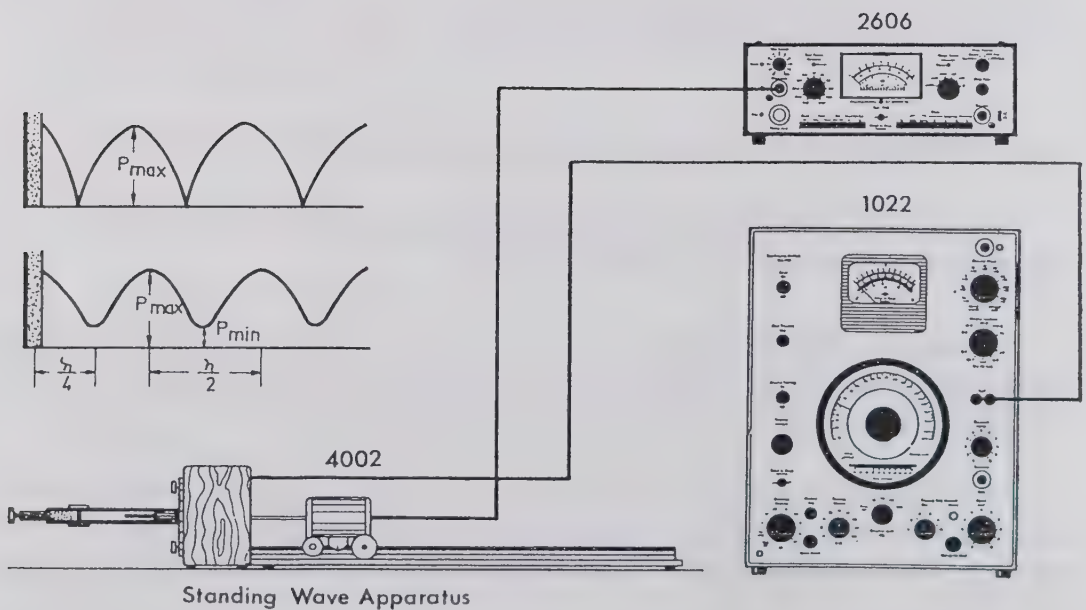


Fig.6.8. Use with Standing Wave Apparatus 4002

moved to a position of minimum sound pressure and the absorption coefficient read off. By increasing the amplification by 10 or 20 dB the minimum reading can be taken from the 0–70% or 0–30% scales.

Further information on the operation of the Standing Wave Apparatus 4002 can be found in its instruction manual.

## MEASUREMENT OF POWER SPECTRAL DENSITY.

When the 2606 is combined with a Heterodyne Slave Filter Type 2020, power spectral density measurements can be made.

A special scale (SA 0046) is available which allows the direct reading of power spectral density in  $\frac{V^2}{\sqrt{\text{Hz}}}$ .

The bandwidth compensation  $\frac{1}{\sqrt{B}}$  of the 2020 is used to produce an output of  $\frac{V}{\sqrt{B}}$  which is then squared by the special meter scale. An instrumentation set up with the 2020 driven by a Beat Frequency Oscillator Type 1022 is shown in Fig.6.9. A Sine—Random Generator Type 1024 may also be used to drive the 2020. Further information on the operation of the 2020 can be found in its instruction manual.

For further information on power spectral density measurements our booklet "Frequency Analysis and Power Spectral Density Measurements" is available on request.

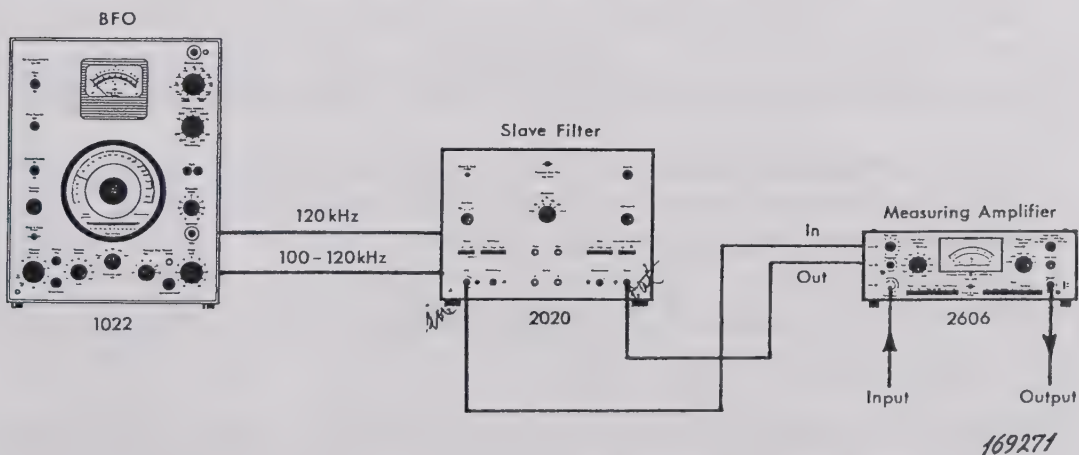


*Fig.6.9. Power spectral density measurements*

## 7. APPENDIX

### THE MEASUREMENT OF SOUND TO IEC AND DIN STANDARDS.

Several standards have been written to specify the desirable characteristics of sound level meters. The most important ones are those published by the International Electrotechnical Commission (IEC) the Deutsche Industrie Normen (DIN) and the United States of America Standards Institute. These committies have published standards for both sound level meters and impulse sound level meters and the 2606, when fitted with a suitable microphone and preamplifier, will conform to them all.

### PRECISION SOUND LEVEL METERS

The IEC have published two standards for sound level meters which will measure continuous sounds. Publication 123 presents requirements for a Sound Level Meter and these requirements are made far more stringent in Publication 179 which is intended for Precision Sound Level Meters. The main points of IEC 179 are mentioned below. DIN 45 633 Part 1 and the new USASI draft proposal for Precision Sound Level Meters are very similar.

- (a) The Precision Sound Level Meter must measure the free-field sound pressure level with an accuracy of  $\pm 1$  dB under specified reference conditions simulating normal use.
- (b) The microphone must have directional sensitivity within certain limits which are specified.
- (c) The indicating instrument must be of the square-law type, and calibration of the meter scale and the error associated with a range shift must be within specified tolerances.
- (d) A meter dynamic characteristic referred to as Fast must be provided. This must produce a meter response to a signal of 200 milliseconds duration which indicates within  $\pm 0.2$  dB of the indication for a steady signal of the same frequency and amplitude. Damping is specified by the requirement that overswing of the steady level produced by a

suddenly applied signal must be within the limits  $\pm 1.1$  dB.

- (e) An alternative dynamic characteristic referred to as Slow is an optional feature. With this response, the meter indication produced by a 500 milliseconds duration signal must fall between  $\pm 5$  dB from the meter deflection produced by a steady signal of the same frequency and amplitude. Overswing due to sudden application of a steady signal must be within  $\pm 1.6$  dB of the final steady indication, and this indication should not differ from the level indicated with Fast characteristic by more than 0.1 dB. Frequency ranges in which these two dynamic characteristic must be met are specified.
- (f) Specifications are also laid down for the maximum permissible sensitivity to external influences: the influence of the sound field on the meter in the absence of a microphone signal, vibrations, magnetic fields, electrostatic fields, temperature, humidity.
- (g) The recommendation also lays down the test procedure which should be employed in checking the compliance of an instrument with these requirements.

It is specifically stated in the IEC Publication that the Precision Sound Level Meter is an instrument which is designed to give an objective measurement which approximates a subjective impression of sound under certain conditions. An instrument which fulfils these requirements can be used for assessment of most continuous sounds. Measurement of discontinuous sounds or sounds of very short duration must be treated separately.

## IMPULSE PRECISION SOUND LEVEL METERS

The problem of how to produce a meter reading which reliably approximates a subjective impression of a sound of short duration (considered as duration from 1 to 100 milliseconds) has been a research topic of considerable interest for some years. The difficulty lies in the specification of a meter response characteristic which closely approaches the rise time of the human ear and stores, averages, and "forgets" the short duration signal in a similar way to the human brain. The German Standard DIN 45 633 Part 2 and the IEC draft for the extension of Publication 179 have been attempts to make these specifications, and no fundamental differences exist between the two recommendations. The main points of the IEC draft are summarised below.

- (a) Impulse Sound Level Meters must have the same characteristics and response to steady sinusoidal signals as Precision Sound Level Meters described in IEC Publication 179.
- (b) To safeguard against harmonic distortion caused by the over-driving of amplifiers by the peaks of high crest factor signals, overload indicators should be placed at the amplifier stage prior to a filter and at the input to the meter rectifier.
- (c) The minimum crest factor capability of the rectifier circuit is specified as 5.
- (d) Response time constant of the rectifier should be 35 milliseconds for both rise and decay. A storage circuit retains the applied signal, however, and on removal of the signal it causes a decay in meter deflection with a 3 sec.  $\pm 0.5$  sec. time constant. The rise time of this storage circuit must be less than that of the rectifier.
- (e) The recommendation also lays down the test procedure which should be employed in checking the compliance of an instrument with these requirements.

It can be seen, therefore, that an Impulse Sound Level Meter is an instrument that approximates a subjective impression of a short duration sound. It cannot be used for the objective analysis of shocks and other pulses, which must be analysed in a conventional manner.

#### **COMPLEMENTARY EQUIPMENT NEEDED TO CONFORM TO PRECISION AND IMPULSE PRECISION SOUND LEVEL METER STANDARDS.**

The additional equipment required to make the 2606 a Precision or Impulse Precision Sound Level Meter is simply a microphone and a microphone preamplifier.

The microphone, must have a frequency range and omnidirectional characteristics (with associated preamplifier) that meet IEC 179 standards (Points (a) and (b) Precision Sound Level Meters). The B&K condenser microphones that meet these standards are shown in table I.

| Cartridge Type                                            | 4138                       | 4135              | 4136             | 4133             | 4134                  | 4144 *          | 4145             |
|-----------------------------------------------------------|----------------------------|-------------------|------------------|------------------|-----------------------|-----------------|------------------|
| Approx.<br>Open Circuit<br>Sensitivity $\frac{mV}{N/m^2}$ | 1                          | 3 - 5             | 1 - 2            | 10 - 15          |                       | 55              | 50               |
| Frequency Range<br>With 2606 $\pm 2$ dB                   | 8 Hz -<br>140 kHz          | 8 Hz -<br>100 kHz | 8 Hz -<br>20 kHz | 5 Hz -<br>40 kHz | 5 Hz -<br>20 kHz      | 2 Hz -<br>7 kHz | 2 Hz -<br>18 kHz |
| Frequency<br>Response                                     | Free Field<br>and Pressure | Free Field        | Pressure         | Free Field       | Pressure<br>and Rand. | Pressure        | Free Field       |
| Approx.<br>Dynamic Range <sup>o</sup><br>with 2606 (dB)   | 76 - 175                   | 64 - 162          | 70 - 170         | 32 - 153         |                       | 15 - 140        |                  |
| Diameter                                                  | 1/8"                       | 1/4"              |                  | 1/2"             |                       | 1"              |                  |

<sup>o</sup>Range from 5 dB above equivalent A-weighted inherent noise level to 4% harmonic distortion.

\*This microphone does not conform to IEC 179 since its frequency range does not extend from 10 Hz to 12.5 kHz.

Table I.

The choice of microphone will depend on the measurements to be undertaken. It is important to note that the smaller the microphone size the wider is its frequency range and the better its omnidirectivity but the lower its sensitivity. Thus with the smaller microphones the lower limit of the dynamic range is higher but considerably greater noise intensities can be measured.

The 1" Condenser Microphone 4144 is especially suitable for use in audiometry or anywhere a pressure response is required.

The preamplifier required for a particular microphone and any additional accessories that are available with the combination, can be seen in Chapter 5, "Accessories".

## THE OPERATIONAL REQUIREMENTS TO MEET PRECISION AND IMPULSE PRECISION STANDARDS.

The conditions under which the equipment should be used are identical, whether continuous or impulsive noises are to be measured.

Care must be taken to avoid reflections, from the instrumentation and the operator, affecting the sound field and therefore producing inaccuracies in the measurements. Maximum reflections from a human body occur around 400 Hz where inaccuracies of up to 5–6 dB are possible. At frequencies of 1000 Hz and higher, reflections can be caused by the Measuring Amplifier.

For these reasons, it is recommended to place the microphone some distance away from both the instrumentation and the operator. The normal 2 m. cable of the preamplifier is usually sufficient for these purposes. The microphone and preamplifier should be held firmly by means of a tripod (eg. B&K UA 0049) or something similar. The Extension Rod UA 0196 can be used to remove the microphone from the effect of the tripod.

Having set up the instrumentation the operator can check his influence on the sound field by moving his position relative to the microphone and noting if any change in meter reading occurs.

Further information on the measurement of sound can be obtained from our booklet "Acoustic Noise Measurements" as previously mentioned.

## 8. SPECIFICATIONS

### Amplifiers

|                                    |                 |              |
|------------------------------------|-----------------|--------------|
| Frequency Response without filters | 10 Hz to 50 kHz | $\pm 0.2$ dB |
|                                    | 2 Hz to 200 kHz | $\pm 0.5$ dB |

Phase shift see Fig.2.16.

Phase difference between two 2606's:

Over the range 20–20 kHz the phase difference between the input stages of two 2606's is  $< 2^\circ$ .

Over the range 5–20 kHz the phase difference between the input and output stages of two 2606's is  $< 5^\circ$ .

|                     |                                           |
|---------------------|-------------------------------------------|
| Total Amplification | 114 dB                                    |
| Temperature Range   | $-10^\circ\text{C}$ to $50^\circ\text{C}$ |

### Built-in Filters

High Pass 22.4 Hz:

|    |         |             |    |              |
|----|---------|-------------|----|--------------|
| At | 2 Hz    | attenuation | is | 70 dB        |
| -  | 4 Hz    | -           | -  | $> 60$ dB    |
| -  | 8 Hz    | -           | -  | $> 40$ dB    |
| -  | 16 Hz   | -           | -  | $> 18$ dB    |
| -  | 22.4 Hz | -           | -  | $3 \pm 1$ dB |
| -  | 32 Hz   | -           | -  | $\pm 0.5$ dB |

Low Pass 22.4 kHz:

|    |             |             |    |              |
|----|-------------|-------------|----|--------------|
| At | 19 kHz      | attenuation | is | $\pm 0.5$ dB |
| -  | 22.4 kHz    | -           | -  | $3 \pm 1$ dB |
| -  | 32 kHz      | -           | -  | $> 18$ dB    |
| -  | 64 kHz      | -           | -  | $> 40$ dB    |
| -  | 125 kHz     | -           | -  | $> 60$ dB    |
| -  | $> 125$ kHz | -           | -  | $> 60$ dB    |

## Weighting Networks

A, B and C to IEC Recommendation 179  
D to proposed standard. See Fig.2.3.

## External Filter Connections.

|                  |                     |                |
|------------------|---------------------|----------------|
| Ext. Filter In:  | Output Impedance    | 10 $\Omega$    |
|                  | max. output voltage | 5 V peak       |
| Ext. Filter Out: | Input Impedance     | 146 k $\Omega$ |

## Attenuators.

Range 0—150 dB in 10 dB steps.

### Input Section:

10 dB steps.

Accurate to within  $\pm 0.1$  dB at 1000 Hz  
relative to "100 mV" position

### Output Section:

10 dB steps.

Accurate to within  $\pm 0.1$  dB at 1000 Hz  
relative to "X1" position.

## Sensitivity.

Full scale deflection for 10  $\mu$ V to 300 V in 10 dB steps.

## Meter Damping.

"Fast" and "Slow" in accordance with IEC Recommendation 179.

"Impulse" in accordance with DIN 45 633 pt. 2 and proposed extension to IEC 179.

"Impulse Hold" indicates maximum RMS level of input signal. Rise time constant 35 m.sec. Decay time constant approx. 30 min at 25°C.

## Meter Indication.

Crest Factor Capability: 10 at full scale deflection, increasing to 40 at  $-2$  dB.

See also Fig.2.9a.

|                 |                                                                                         |
|-----------------|-----------------------------------------------------------------------------------------|
| Meter accuracy: | For crestfactor up to 10                                                                |
|                 | $\pm 0.5$ dB from $-2$ dB to 10 dB                                                      |
|                 | $\pm 1$ dB from $-10$ dB to $-2$ dB                                                     |
|                 | Add 0.5 dB to these values for crest factor up to 20 and 1 dB for crest factor up to 40 |

See also Fig.2.9b.

## Overload Indicators.

|                       |            |
|-----------------------|------------|
| Input overload level  | 5.6 V peak |
| Output overload level | 5.6 V peak |

Lamps light for overload pulse longer than 1 msec and remain lit for 0.5 sec minimum.

## Input Impedance.

At "Direct" input,  $1\text{ M}\Omega//50\text{ pF}$ .

## Outputs.

AC:

|                                                             |                                   |
|-------------------------------------------------------------|-----------------------------------|
| Output Impedance                                            | $50\ \Omega$                      |
| Minimum Load Impedance                                      | $5\text{ k}\Omega$                |
| Output voltage corresponding to full scale meter deflection | 5 V RMS (sine)                    |
| Maximum Output                                              | 50 V peak                         |
|                                                             | 10 mA                             |
| Noise                                                       | 55 dB below full scale deflection |

DC:

|                                                                |                |
|----------------------------------------------------------------|----------------|
| Output Impedance                                               | 25 k $\Omega$  |
| Minimum Load Impedance                                         | 5 k $\Omega$   |
| Output voltage corresponding<br>to full scale meter deflection | 730 mV         |
| Maximum Output                                                 | 1 V<br>0.06 mA |

Direct short circuit of the Recorder socket when set to DC will not affect the meter reading.

**Inherent Noise.**

|             |                    |         | $\mu$ V RMS |
|-------------|--------------------|---------|-------------|
| Linear      | 2 Hz to 200 kHz    | approx. | 7           |
| Linear      | 2 Hz to 22.5 kHz   | -       | 2.5         |
| Linear      | 22.5 Hz to 200 kHz | -       | 7           |
| A—weighting |                    | -       | 1.5         |
| B -         |                    | -       | 1.5         |
| C -         |                    | -       | 1.5         |
| D -         |                    | -       | 4           |

All the above values are with maximum amplification with the input short circuited.

**Power Requirement.**

AC: 100, 115, 127, 150, 220, 240 Volts 50—400 Hz 30 Watts.  
DC: 12 V  $\pm$  10% 24 Watts.

|                        |                             |
|------------------------|-----------------------------|
| Warm—up time:          | 20 sec.                     |
| Operating Temperature: | —10°C to 50°C               |
| Storage Temperature:   | —25°C to 60°C               |
| Humidity Range:        | 0 to 90% relative humidity. |

## Dimensions.

|            |        |                   |
|------------|--------|-------------------|
| A cabinet: | Height | 13.2 cm (5.2 in)  |
|            | Width  | 38.0 cm (15.0 in) |
|            | Depth  | 20.0 cm (7.9 in)  |

**Weight.** 7.4 kg (15.5 lb)

## Accessories Supplied.

2 x 3 pin plugs  
2 x B & K coaxial plugs  
1 power cord and plug.

## Scales Supplied.

|         |                                                                                                                                |
|---------|--------------------------------------------------------------------------------------------------------------------------------|
| SA 0037 | Voltage scale (with dB).                                                                                                       |
| SA 0038 | Voltage scale in dB re. 1 $\mu$ V.                                                                                             |
| SA 0039 | Sound Level in dB re, $2 \times 10^{-5}$ N/m <sup>2</sup><br>for microphones of sensitivity 26–90 mV<br>per N/m <sup>2</sup> . |
| SA 0040 | As above but for microphones of sensitivity<br>2.6–10 mV per N/m <sup>2</sup> .                                                |
| SA 0071 | Acceleration scale (with dB) for<br>accelerometers of sensitivity 6–17 mV/g.                                                   |

### Scales Available.

- |         |                                                                                                                          |
|---------|--------------------------------------------------------------------------------------------------------------------------|
| SA 0045 | Absorption Coefficient scale for use with Standing Wave Apparatus Type 4002.                                             |
| SA 0046 | Power Spectral Density scale for use with Slave Filter Type 2020.                                                        |
| SA 0061 | Sound Level in dB re. $2 \times 10^{-5}$ N/m <sup>2</sup> for microphones of sensitivity 0.8–2.6 mV per N/m <sup>2</sup> |
| SA 0073 | As above but for microphones of sensitivity 0.4–1.6 mV per N/m <sup>2</sup> .                                            |
| SA 0070 | Acceleration Scale (with dB) for accelerometers of sensitivity 17–60 mV/g.                                               |
| SA 0074 | As above but for accelerometers of sensitivity 1.7–6 mV/g.                                                               |
| SA 0075 | As above but for accelerometers of sensitivity 60–170 mV/g.                                                              |





## **B & K INSTRUMENTS:**

### **ACOUSTICAL....**

Condenser Microphones  
Piezo-Electric Microphones  
Microphone Preamplifiers  
Microphone Calibration Equip.  
Sound Level Meters  
(general purpose-precision-  
and impulse)  
Standing Wave Apparatus  
Tapping Machines  
Noise Limit Indicators

### **ELECTROACOUSTICAL....**

Artificial Ears  
Artificial Mouths  
Artificial Mastoids  
Hearing Aid Test Boxes  
Telephone Measuring Equipment  
Audiometer Calibrators  
Audio Reproduction Test Equip.

### **STRAIN....**

Strain Gauge Apparatus  
Multipoint Panels  
Automatic Selectors  
Balancing Units

### **VIBRATION....**

Accelerometers  
Accelerometer Preamplifiers  
Accelerometer Calibrators  
Vibration Meters  
Magnetic Transducers

Capacitive Transducers  
Vibration Exciter Controls  
Vibration Programmers  
Vibration Signal Selectors  
Mini-Shakers  
Complex Modulus Apparatus  
Stroboscopes

### **GENERATING....**

Beat Frequency Oscillators  
Random Noise Generators  
Sine-Random Generators

### **MEASURING....**

Measuring Amplifiers  
Voltmeters  
Deviation Bridges  
Megohmmeters

### **ANALYZING....**

Band-Pass Filter Sets  
Frequency Spectrometers  
Frequency Analyzers  
Real-Time Analyzers  
Slave Filters  
Psophometer Filters  
Statistical Analyzers

### **RECORDING....**

Level Recorders  
(strip-chart and polar)  
Frequency Response Tracers  
Tape Recorders

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